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PROCEEDINGS

OF THE MICHIGAN SCHOOLMASTERS' CLUB AT THE THIRTY-SEVENTH MEETING HELD IN ANN ARBOR MARCH 27, 28, AND 29, 1902.

Ann Arbor
University of Michigan
1902

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PROCEEDINGS OF THE THIRTY-SEVENTH MEETING, HELD AT ANN ARBOR, MARCH 27, 28, AND 29, 1902

PAPERS

EDITED BY THE CHAIRMEN OF THE VARIOUS SECTIONS

GENERAL MEETING

Preparation for Life, and Preparation for College.

PROFESSOR GEORGE REBEC, UNIVERSITY OF MICHIGAN

One question usually involves many questions. When we ask, "Does the same education prepare best both for college and for life," our whole answer is contained in what we understand by "preparation for life," and by "preparation for college." To these latter questions, therefore, we must address ourselves.

I shall say my worst first. It is my opinion that the best preparation alike for college and for life is culture. I hurry to add, however, that though I mean what I say, the extravagance is rather in the term than in the thing really intended. Permit me to enlarge.

To begin with, by culture I do not mean simply the fragile fruits of a course of so-called select and high-toned studies. Culture embraces the whole substantial business of self-realization—self-fulfillment on every side, spiritual and physical,—and this not merely in a private, individual way, but of the man as a social being. It is true that the practical educator, while laboring with his whole strength to instill in the youth the love of his social self and to call forth the richest growth possible of that self, yet will always endeavor not to run counter to nature in the man. He will have regard to his primitive spontaneous ego, its quality, interests, and aptitudes, and will so try to direct him as to utilize for his social being and not merely thwart, the natural man in him. A too steady crucifixion of the flesh never leads to the highest human product, and in the average case is more than likely merely to fag and kill the life and spirit out of a man. The watchword of

modern pedagogy is, find an outlet for nature. And yet, when the situation arises wherein conflict between the private and universal self is inescapable, the private must be taught to yield. The man must be trained to the habit and strength to compel it to yield; he should be moulded to feel the joy of another and higher fulfillment of self in the very defeat of self. Self-sacrifice, duty, hardship, routine are realities in life; they are with us not only in certain grand crises of existence, but in a thousand and one trifles every day and almost every hour. I do not, under common sense, see of what else the moral conflict and hard moral lift consist. And yet, from the way in which so much of our nineteenth century pedagogy has interpreted the gospel of the "Return to Nature"—of freedom, spontaneity, and interest in education—these would seem to be things to be obviated. While as ready as any man to be dubbed an apostle of culture, I part company from the mere preachers of the pleasant. I believe education in large part to be *through* and even *for* self-sacrifice, hardship, obedience, discipline, mechanism, routine.

The just-named conditions of unfreedom, we might observe, come into the schoolroom in two ways. In part they are incidental to the carrying out of the educational program. More or less of mechanical division into grades and classes, courses of study, abstractly separate subjects, arbitrary times and seasons, more or less changing of teachers and fellow-pupils and schools, more or less in the way of interruptions and the thousand and one things we call accidents, there must always remain with us. In fact, the residue of it all will always be sufficient fully to justify the continuance of earnest efforts to overcome it. So far as it cannot be absolutely eliminated, the intelligent teacher will endeavor, to the extent that he can, to reconcile it with his purposes—he will transform his hindrances into opportunities, and make of precision, regularity, clear-cut distinction, change, intermission, etc., downright stimulants of interest and enthusiasm. For the rest, if some of these freedom-marring elements still remain over, the wise teacher will not be too distressed. He will not become a mediaeval worshipper of hardness; he will not countenance it needlessly, much less feel obliged to go far out of his way to find it; but seeing it inevitably in his path, will he not recognize that it is the very stuff of which a great part of real life is made? Real affairs do not wait upon our moods and pleasure: those of us who try to go on the æsthetic expectation that they will, know how little we do do. The dead lift is a living fact.

In part the factors of mechanics, routine, and pain come into the school because they are innately involved in education itself. You can't completely get rid of preliminary and instrumental studies, which are mere cold means to an end other than themselves. The boy who will not learn grammar, cannot know Latin. Of course, here again the educator must labor on to get rid of the old-time love of the dry and disagreeable. He may count upon it, that *serious* learning, like serious practical living and social adjustment, involves enough of the hard and unpleasant and remote without our making very special search after it. He will therefore strive, as far as in good sense he dare, outright to get rid of it; or where he cannot directly do this, he will try to transform it, by awakening an interest in it for itself through finding for it a meaning in the student's life in general; or, further still, he may frankly concede that a given study is only a means, but will try to help his pupil vividly appreciate that it is and how it is a means, and as such vital; or—last resource of all—he may to some extent legiti-

mately attempt even to arouse an adventitious interest for it. But beyond this, he will remember that he has to do here only with an illustration of a phase of the real nature of things themselves, a phase which, if he is to train for the actual conditions and activities of the world and not for a mere kindergarten paradise of pleasant illusion, cannot be blinked and sentimentally dodged, but needs to be reckoned with as a positive and radical factor in effective education itself.

Evidently, we intend that culture shall include rigor and regard for the actual serious requirements of existence. But does not preparation for life involve something more than these generalities, however excellent they may be? What shall we say once more to the never-silenced grumble of the materialistic public that the youth, whether in the secondary or any other school, ought to be learning to make a living and to do actual ordinary things? Have we not here a demand fatally hostile to the liberal sort of training we have just been describing, and may not our liberal culture itself in a way be inimical to the prosaic practicality that fits a man for the world? Though this anxiety about a living should command the respect due it as born of the immemorial grim experience of the people, nevertheless our answer too must continue to be the old immemorial one, "Man shall not live by bread alone." Especially in these days of the weakened authority of the Church must our schools be the shrines of idealism: it will be a dreary day for our civilization when we accept the motto that the whole end of life is to get a livelihood for ourselves and ours. China even has not unqualifiedly assented to that maxim. Moreover, it is not simply an ideal, but the unadorned truth that the man is more than the carpenter and the man's relations more than the carpenter's; so that the schoolmasters and mistresses who almost everywhere, at least in this land, have been struggling to keep our popular schools from sinking into mere institutes for the three R's and bookkeeping, have been waging a fight not only for idealism but for fact. And yet is there not some justice in the brusque retort of the people's elders, that for all that the man must live? Bread *is* the staff of life; and since it is the doom of the mass of men to earn their bread, why not provide for their education in the bread-studies before giving room to the studies that furnish only the desserts to life's banquet? Of course, our answer is, that the most effective way of earning your bread is to equip yourself to earn much more than your mere bread. An awakened mind, a disciplined will, ready sensibilities, and a trained eye and hand are indefinitely more to a boy or girl than any amount of mere knowledge of technical bookkeeping or blacksmithing, or cooking and sewing. Still, is this the sum of the whole matter? Is it the fact that simple intelligence in general necessarily makes the good bookkeeper, or that ability to throw the ball or put the shot trains the blacksmith's arm, or skill in picking out the shades on colored cards develops the milliner's peculiar taste? Quite obviously not. Accordingly, if the end of all education is wholeness of life, and the foundation of life is a living, why should not our schools, on behalf of the vast majority to whom the living can come only through their own making of it, provide the specific training that alone will make the making of the living possible? To be sure, it is a millennial notion to expect the schools to be able to give minute instruction in all the arts and trades; however, callings, as Professor Dewey has lately been so well pointing out, fall into typical groups. Why not, therefore, do at any rate as much as we can, by bunching our pupils together under one or the other

of these vocation-groups, according to their aptitudes and carefully observed tendencies, and instructing each as far on as possible along his proper line? The objection that of course recurs is the same one,— that in spite of all, the man is more than his trade, that there is a wider knowledge and a wider human nature, and there are wider human relationships than those of mere craft and business, and that these must not be subordinated to any mere scheme of giving the man a trade: in the competition of studies in the common school, the so-called practical must yield to the more broadly human. I agree completely with this contention, and so far enroll myself with the idealists and professors against what is usually supposed to be the position of the hard-headed practical men and business-men. Indeed, it asks no profounder reason to bring one to agree here, than to point out that any defect of mere detail of technical knowledge is more easily made up out in the ordinary world, than is a deficiency of that inward education that makes for largeness of outlook and being. Does this alternative, though, of choosing between the mercenary and the culture-studies press so hard as we are commonly disposed to think it does? I cannot help feeling but that, with the best intentions, our teachers — more especially in the high schools — have been quite wrong-headed in this connection. On the one hand, perceiving instinctively the soul-killing drift of the gospel of naked utility, they have been impelled into a blind, wholesale reaction; while on the other hand, like all the rest of us, they have been traditionally given to separating the world of studies, as Professor Dewey puts it, into two regions, — the high-toned and the vulgar; and the distinction has largely been based on whether or not the particular study had anything to do with ordinary life and affairs. Remoteness and aloofness have been supposed somehow to confer aristocracy upon studies as upon men. Now I am not ready to assert that all subjects are indifferently of equal culture-value; but I do hold that the differences have been greatly exaggerated. What is there about bookkeeping and banking or the use of machinist's tools that should make it impossible to make them play into general intellectual interest, general purpose, and even general human sentiment? Let us, besides, remember that man — and especially the child-man — is an imitative creature, and one living much in expectation, and that what he sees to imitate and what he expects to be and do, deeply stirs his interest — that motive power without whose eager response every endeavor to bring a man to selfhood is vain. But now what he sees about him to imitate, and what by the overpowering preponderance of obvious example he expects himself to be at, is precisely the common useful crafts and occupations. Our small boy, unless he is a hopeless little prig, does not play or look forward to being missionary or silver-tongued orator, but fireman and farmer. Everybody knows too the general success manual training has had in the schools with the children. The commonplace, practical subjects, it would appear, have even a certain advantage in the purely cultural aspect. I am not sure also but that the thought that the subjects are to help him earn a living will not have a certain leverage of arousing an interest in the student — an interest capable of being measurably exploited in a general cultural sense. Clearly, then, I can see no reason for not yielding to the practical fathers and mothers a large degree of what they want, — the introduction of materially useful branches to a prominent place in the curriculum of all our preparatory schools higher or lower.

Only here come in the colleges with their demand. It need not trouble us just now that our colleges have ceased to be simple in their aims and requirements, having become a sort of hodge-podge of a maturer continuation of the same culture course pursued in the high schools, and a lot of preliminary or inchoate professional studies of the true university, that is, graduate and professional school type: for our purposes, their various distinctive demands on the more elementary schools are reducible to one,—the demand for special scholastic knowledge. Now surely the preparation of men for college—which itself is but the preparation of men for forms of leadership and activity in the community without which the community is largely blind and its very everyday work largely meaningless—is a legitimate and indispensable part of the business of the secondary school. But how are we going to get this function done, if we insist on introducing into the high school all manner of studies preparatory for the world? Shall we not end in utter bewilderment with every vestige of unity and simplicity of purpose vanished from our program? No doubt, the problem is a very real one, and not to be settled by any man off-hand. And no doubt that in its settlement numerous balancings and compromises must be made. In arriving at any solutions, however, two considerations ought to be weighed. First, have we not been traveling with rather exaggerated ideas of the amount of technical, special accumulation our boys and girls must be asked to bring with them to college? I may be disclosing myself as hopelessly unscholarly, but I frankly avow that my experience as a teacher has been that, even for advanced special work, the young man or woman who, though his technical preparation be quite deficient, yet is one who has come to himself, whose mind has been found out and his free interest stirred to movement, is indefinitely preferable to the person who has been thoroughly through the formal grind, but never has come into the intellectual possession of himself. I believe, too, that this is the regular experience of teachers. But we have seen that self-development is attainable through many other than the narrowly scholastic means. Why not, then, bravely act up to our convictions and the facts in this matter of college-entrance requirements? Still, the case is not all one way here either. The boy who has not ground his Latin grammar and prose cannot expect profitably to read Horace or Lucretius, just as he cannot work his analytical geometry if he knows nothing about common algebra. The course that looks to life and that which prepares for college are not identical. Each unavoidably has its special bias; and so we are obliged to face a second consideration, namely, whether, like the Europeans, we shall not be obliged to have two distinct courses in our secondary-school system. Our American democracy, with the constant shifting of social classes and the suddenness with which, almost in an hour, the fortunes and prospects of a child in this country may alter, of course precludes of our ever drawing any such invidious line of demarcation as exists in Germany between the folkschool and the gymnasium. There must be fairly free intercommunication, a reasonably easy transition from the popular to the college-preparing course, and *vice versa*. As we have been saying, a great share of the so-called practical studies should be accepted in a liberal spirit as meeting college requirements; while everybody but a rampant champion of the three-months-in-a-business-college-and-then-into-business idea will concede that a very large portion of the more learned material has training-power of just the kind that even the plain people want. After this, what cleft remains between the college-

preparing courses and the courses preparatory more directly for life, need, perhaps, not to be so hopelessly wider than that between the boy's studies and girl's studies which nevertheless manage to subsist side by side in the same school.

However, suppose that after all is said and done, there persists a remainder of conflict between the popular and the scholastic studies, between the interests of the many who are looking towards the world and the relatively few whose eye is turned in the direction of college? I am more loath to commit myself to an answer than from my way of putting the alternative might seem. I hardly know which to prefer, or more accurately, which to esteem less, a democracy which slights its provisions for the secure prosperity of the higher science, art, and philosophy, or an aristocracy of superior culture which pursues its own concerns in abstract detachment from the well-being of the mass. Nevertheless, if we are to hold to our faith in our democratic gospel that the provision for the great majority at even a lower level is in the long-run better for society than the provision at a high level for the minority, we must, I suppose, decide that the sacrifice must be in the direction of the interest of the smaller number. In the ordinary American high school, Greek and even Latin must be prepared to take a back seat as against United States history and hygiene; and it behooves the professors of these and kindred subjects obviously for the benefit of the select college-going remnant, to ask themselves whether even now the time has not arrived for, say, such a concession to democratic prejudice as providing for beginning-classes within the college course itself, ideally or even pedagogically unsatisfactory as this, from every other point of view, may be.

A great deal of the tendency still survives among us to identify outright the scholastic, technically learned studies with the culture studies. This tendency partly springs from the natural error of confusing that which is an occupation of the few select, with what is itself select; but more particularly does it arise from tradition. First of all, it is a remnant of mediævalism among us. In the Middle Ages, culture — if we may use the word in the connection — implied, not the modern pursuit of self-realization, but the literal gospel of self-renunciation. Even the moderate maxims of the time call, in all things, for humility and obedience to authority. The striving everywhere is to exhibit the spirit submissively receptive, disciplined, mortified; and these things are what constitutes mundane culture — if such a thing may be said to exist at all for an era to which the soul's proper being lies only in a blessed vision of the Beyond. For such an age, clearly, there can, in the training of the mind, be no harm but only virtue in reducing study to mere vigils of memory and painful persistence backed by literal physical fast and flagellation; just as for it the baldest, most formal grammar, rhetoric, logic, or arithmetic are genuine culture-studies; because for it the relation of studies to interest and the free natural life of the spirit is a matter only of negative concern. For such an age, clearly, culture can be only an external thing. When the Renaissance appeared, it is true it changed men's mood and reinstated the ideal of self-development; so that no longer could culture be submerged in the sapless learning that to this day is called scholastic. Nevertheless the new ideal of culture was obliged to be largely reminiscent — its best stimulus and suggestions were to be found back in ancient Greece and Rome. Therefore bare learning, though it ceased to have a cultural virtue in itself, became emphatically the

key to culture; and because it was the key to culture, men, by a natural piece of ill-logic, encouraged by a historic reaction towards mediaevalism which we cannot here enter upon, identified it with the substance of culture; and they continue numerously still to do so. Both the mediaeval and the later reactionary exaggerated conceptions of the worth of formal learning still largely prevail in our schools; and yet the simple fact is, that those studies whose obvious first distinctive mark in the high school is that they are technical preparation to special advanced work in the college, as regards their cultural value resemble more closely than any other branches those very practical ones against which, in the name of culture, they so often wage war. Culture, whatever else it includes, presupposes ideas, and sensibility to ideas, outlook, perceptive insight, and the living spirit; but wherein (to be moderate) does the first year of Latin, or Greek, or French, or a good deal of mathematics as taught, further all this markedly better than say so much household-economy or shopwork? I do not assert that scholastic studies — the most undisguised of them — have no cultural worth; nor that this worth cannot be increased; nor even that any irreducible remnant of dead weight about them is an unmitigated evil; but only that their real justification in the secondary curriculum remains their instrumental character, while their cultural quality for the most part is subordinate — in some respects inferior to that of the despised bread-and-butter subjects, which possess the interest of direct utility and relation to life. If this fact were better realized, it might spare us, for instance, such heaven-crying spectacles as a principal trying to induce a lad who in all human likelihood will never see the inside of a college, to take the high school two-years course in Greek, "because of the superior culture there's in it"!

All that we have so far said, throws light on what are the rights and proper place of those higher professional studies that nowadays are crowding their way down not only into the college but the high school courses. The attitude of educators towards these higher practical studies has been very much the same as towards the humbler practical ones. Teachers have been prone to feel as Aristotle did, when he forbade the young citizens of his ideal commonwealth not only to perform music professionally, but even to acquire skill up to the professional point. Professionalism seemed, to Aristotle, to introduce an illiberal element into education, and to distort the man from the pursuit of an unbiased, symmetrical self-development. Aristotle overlooked the possibility that a man *may* truly realize himself in a vocation. Also he did not contemplate a social order other than his own,—one in which every man *must* bend himself to a special function, there being normally no provision, on the one hand, for an aristocratic leisure-class which shall be exempt from the necessity of any calling in particular, and, on the other hand, for a servile class doomed inexorably to the dull, deforming round of narrow toil. Lastly, Aristotle and his followers have forgotten that general culture is not gotten through studies in general, but must be worked out by every man along his own line—yea, even if it be his professional line,—and must gain its breadth by being carried so deep and far as to be brought into connection with things and life in all directions. However, if such has been our mistake in the past, just at present we are drifting into notions exactly the reverse. Members of college faculties are breezily advocating the proposition that a man's general culture will take care of itself if he only thoroughly turns his

attention to getting his profession—and then getting his profession is interpreted in the narrowest technical sense. What are we to say to this new doctrine? I for one confess that I am bewildered in the presence of a pedagogical philosophy whereby Plato, Shakespeare, and the New Testament become educational aberrations, or something to be consigned to private reading-circles and the Sunday schools. I still must hold that the very heart of education is general culture—ideas, broad human sympathies, and broad human capacities. In the secondary schools, and in the college itself so far as it continues a part of the secondary school, professional studies have a place only in so far as they are soundly reconcilable with the more vital concern of culture. They have even less right there than have the vulgarer useful studies in the lower schools, because they are not a concession to an urgent need of getting a living. The proper place for strictly professional studies—for the preparation of doctors, lawyers, bankers, foresters—aye and teachers too, is in the graduate and professional school; and even there—as all enlightened judges will urge,—they should be conducted on a broadly liberal foundation, with a broadly liberal outlook.

In conclusion, let us summarize quickly. The aim of the secondary school properly is and must remain culture. However, the hostility of practical and professional studies to culture is not so great as has, under the influence of tradition and false aristocratic feeling, been too usually assumed. Furthermore, this incompatibility may, by enlightened teaching, be still further diminished—to the benefit of the useful and professional knowledge itself. Lastly, in the working out of these matters, at any rate in the more popular schools, it is the distinctively learned subjects that must expect to make most concession, though the serviceableness of these branches themselves to the cultural ends that are at the bottom of the schools, is capable of very large increase.

ENGLISH SECTION

Discussion of English Masterpieces Required for Entrance to College

PRINCIPAL JAMES H. HARRIS, MICHIGAN MILITARY ACADEMY

At the outset permit me to say that my discussion, while including the subject as given above, will take a somewhat wider range, and besides discussing some of the particular books required for college-entrance, will consider some of the principles and conditions which underlie the choice of reading matter, and which should, in a measure, determine the selection.

Last summer in a paper read before the English Section of the Department of Secondary Education at Detroit, I expressed my belief that the adoption of unified requirements in English was a necessary and eminently progressive step in the evolution of the English curriculum. The chaotic conditions that prevailed,—both on the side of the colleges, no two of which made the same requirements, and the secondary schools, where individualism had run mad,—were so subversive of economy of effort and of unified and satisfactory results that it became imperative that the atmos-

phere be clarified, the woful waste of time and energy remedied and the English requirements brought by force into something of unity and order. This step, as I have intimated, was absolutely necessary to the integrity, security and continued effectiveness of the English curriculum, and receives its justification in the unquestioned good it has done in bringing order out of chaos and in attaching some measure of unity and fixity to the work in English. All praise should be given to the Committee on College Entrance Requirements in English which so bravely attacked so serious a problem and so successfully worked it out.

But that step, important and beneficial as it was, can hardly be looked upon as final. At best it was a unity forced, artificial, superimposed. It is not a unity from within, possessing the vitality and permanency of life, but is an artificial unity and only of service as it is a necessary step in the evolution toward the higher unity. For of all the branches of instruction in the program of studies, English is, of force, the most fluent and plastic, the least susceptible to rigidity and inflexibility either in form or content. The time can never come, I believe,—until English takes its place among the dead languages,—*Dei diem avertant!*—when the curriculum in English can be as determinable, as restricted, and as final as in the Ancient Languages or in Mathematics. The ends and aims of instruction may, and, I believe, will be more clearly defined, but the means by which those ends are attained will ever vary. So long as English is a living tongue the attempt to give rigidity and permanency to the curriculum cannot but fail. The very term "College Entrance Requirements" indicates at once the source, the strength and the weakness of the existing situation. It is the ever-present witness to the fact that the unity is imposed from without. In a time when the colleges and universities are less and less given to imposing their will upon the secondary schools, we find the rather anomalous condition of a consciously imposed curriculum. Yet it was a necessary imposition, and a situation which the secondary schools seemed unable to cope with alone had to be taken in hand by those in the higher institutions. This is a source of strength, but it is also, as I have intimated, a source of weakness, and the time must come when the problem will be solved from within on the basis of a sound psychology and of sound logical and historical principles. What I mean by this will appear from a study of the conditions which gave rise to the necessity for the interposition of higher authority to bring into order a distinctly chaotic condition. Those conditions were, first, a hazily defined curriculum; second, an absence of specially trained teachers; third, an inadequate time allowance; fourth, the difficulty of fitting students for a most varied assortment of entrance requirements; and fifth, a lack of suitable texts suitably edited. Out of these conditions grew the necessity for collegiate interference and guidance. But these imperfect conditions are in some particulars wholly remedied, in others rapidly becoming so. We are attaining a more definite conception of the end and purpose of our English instruction; we are granting it a larger allotment of time; we are equipped with numerous and suitable texts—good tools with which to carry on our craft;—we are strengthening our course of study; and above all—and the underlying strength of all—we are securing a body of teachers trained for this work as are those in the Foreign Languages, in Science and in Mathematics. With the removal, by a natural process of growth, of the conditions which brought about the imposed curriculum in English, we may look for a reconsideration of its

claims to permanency, and discover whether, in the light of the new conditions, certain modifications may not be necessary and some revision of the principles upon which it is based be formulated.

The basis, then, of the reconstruction I have in mind lies in the thought of an inner unity as contrasted with an outer, artificial unity. I acknowledge that the superimposed unity is easier; it relieves us from all care and responsibility; it says 'do this' and we do it:

> "Ours not to reason why,
> Ours but to do or die;"

it makes us secondary clay in the hands of the University potter, and while it may manifest the surpassing artistic cunning of the potter, it,—well, it makes and keeps us just clay!

The elements of this inner unity are three in number, and out of them, I believe, the English curriculum will ultimately be constructed. These elements will be determined, first, by a wide and comprehensive study of the tastes, interests and intellectual attainments of the pupils of secondary age; second, by an exhaustive and scientific study of the books and literature adapted to each particular grade or age; and third, by a study of the principles underlying the historical development of literature. If a course of reading based on such a sound philosophy and psychology as this could be elaborated, the inner unity for which I plead would be attained and the most satisfying results would be achieved. The question of adequate preparation for college, too, would solve itself, and the pupil who was best prepared for life on such a program would of necessity be best prepared for college. We hear much about the best preparation for college being the best preparation for life, but I say the best preparation for life is the best preparation for college.

A PLEA FOR WIDER OPTIONS IN READING MATERIAL

But for the present my first practical application of the theory that the English curriculum must be built up from within and must rest on a study of the conditions and factors that are predominant in the secondary school period, is the recognition of the principle of wider options in our reading material. But, you will say, that involves a reversion to the chaotic, disorderly individualism of the days which we are glad to think are no more. No, I do not mean such a wide-open policy as formerly prevailed; I mean freedom within certain well-defined limits; I mean that instead of four books absolutely and undeviatingly required there should be a list of eight or ten books from which choice might be made; I mean that instead of ten books for general reading, a list of twenty-five should be made within which the teacher might select those best adapted to local or individual conditions or most consonant with his or her own interests, tastes and studies. I am well aware that teachers of sufficient training, literary taste, breadth of view and good judgment to select what is best on any scientific principles, without reference to some idiosyncrasy or one-sided interest, are extremely rare. And to leave complete freedom to these would be to invite a return to those conditions which we all so much deplored. But selection within such limits as I have suggested would, on the one hand, sufficiently safeguard the interests of the curriculum, and, on the other hand, give adequate freedom to that growing class of teachers, who, with a splendid equipment in English, are sanely judicious enough to use the restrictedly wider opportunity to the enrichment of their own souls, the

enlargement of the mental horizon of the pupils and the betterment of the curriculum. To many a well endowed and adequately trained teacher the narrow restrictions of the College Entrance Requirements are a source of baffling discouragement. Seeing the rich feast before their eyes, like Tantalus, they may not taste of it. Shall they constantly be so tortured? Out of the surpassing richness of our unrivaled literature are there only four books which can be carefully studied to advantage and profit? Shall the whole fabric be sacrificed to convenience? The number of books constituting the body of good and imitable literature—literature which it is not only worth the pupil's while to absorb, but which he is prepared to absorb —is so large, and the line of cleavage between the one gem of literature and the other is so fine that it is out of the question to reject the one and insist on the other, save on the assumption of an artificial convenience and a forced requirement.

This leads me naturally to consider the claims of some of the books which are set for careful study and general reading, and to raise the question, *not* whether they should be discarded but whether a wider option might not be allowed. I have no thought in my mind to question the claims of the books recommended, to a place in the hierarchy of English masterpieces. Every one of them is admittedly included in that sacred circle and I would not wish to seem even to question the claims of these masterpieces to a place in that list. I shall merely consider one or two of them in the light of their adaptability to secondary school conditions and their claim to *exclusive rights* as the objects of literary study.

The first masterpiece to which attention is called is Tennyson's Princess. While it is true that this poem is not included in the list for careful study, it is included in the list for general reading, and must perforce be given a place somewhere in the curriculum to the exclusion of something else. There is no question of the artistic greatness of this poem, and some of the intercalary lyrics, notably "The splendor falls on castle walls" and "Tears, idle tears, I know not what they mean," are among the most beautiful in English literature. But why wade through an interminable discussion of the equality of the sexes in order to get a few gems? To boys especially the task of toiling through this long poem is discouragingly dreary and there is great danger of creating in them a distaste for the master poet of English form and versification which they may not ever overcome. It would seem to me that the approach to Tennyson might more happily be made through other avenues.

The second masterpiece for which an option might very reasonably be offered is Burke's Speech for Conciliation. Not that I would exclude it from the list, for its historical as well as its oratorical value amply justify its selection as an example of the form of literature of which it is so splendid a representative, but there might be conditions which would make the selection of another piece of oratory more serviceable, and for the benefit of these an oration of our own Daniel Webster or Wendell Phillips might well be substituted. To drag a class largely composed of girls, for instance, whose argumentative stock in trade usually consists of one word, thro' Burke's elaborate and often fine-spun arguments, is a task to test alike the patience and the wits of the most dauntless teacher.

The cultivation of a style like Burke's would be an anachronism. Why then devote so much time to it or lay so much stress upon it? In the study of Burke the teacher is much of the time warning his class against

his florid diction, his rhetorical digressions, his effusive classicism. No speaker of this day would think of constructing a speech in imitation of Burke. The whole spirit and atmosphere of modern times calls for oratory —even argumentative oratory—of an entirely different type. Again, it requires mature and trained thought to follow Burke's involved argument, and it is doubtful whether, unaided, the average boy or girl in our secondary schools would be able to give an outline of it. And I am inclined to think, as a result of experience and observation, that a practical example of argumentation less complicated and less ornate would better accomplish the purpose in many instances.

I have no thought, let me repeat, of decrying the greatness or importance of the speech. It is one of the masterpieces of one of England's master orators. But I would question the propriety and value of forcing a lot of boys and girls thro' it, especially under a teacher whose appreciation of closely reasoned and logically constructed argument is circumscribed by sex. I should place the oration in the list of books for careful study, but make it optional with one or two other orations such as those suggested above, and let the individual teacher's judgment determine whether it is the best book for careful study with that particular class.

Another bit of literature I should venture to raise some question about is Milton's Comus. Not but that the poem has literary and artistic excellence of a high degree, and moral tone of an unimpeachable character. The trouble is the poem is so flagrantly and flauntingly moral that it vitiates the art.

I have not time to enter into further detailed discussion, but I cannot close without referring to the conspicuous lack of American masterpieces on the list. I am far from being so scoundrelly in my patriotism that I see nothing good in other than the American brand. At the same time one cannot be charged with extravagant patriotism in claiming that at least five or six of our writers are deserving of recognition.

To sum up, then, I would plead for a list of ten books instead of four among those recommended for careful study, from which the teacher might select the four best adapted to her needs and tastes. I would favor a list of twenty-five books for general reading, selected with some reference to historical sequence and to the interests and attainments of the pupils, and in doing that I could not but include at least a few of our American authors. In this way, I believe, we would secure sufficient rigidity to satisfy the convenience of college-entrance examinations and at the same time give sufficient flexibility to the curriculum to broaden the interest and stimulate the activities of our best teachers.

Composition Teaching in the Schools of Mississippi

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It is a significant fact that President Eliot speaks of the introduction of systematic instruction in the English language and literature into the secondary schools as a "tendency." "It may be spoken of," says he, "as a tendency, because the best methods and legitimate aims of this instruc-

tion are still under discussion, and are still being developed by continuous experiments in innumerable schools." However disposed we may be to resent the word "tendency" in this connection, a very little consideration of the question will show that President Eliot is right. Though the study of English is now receiving more attention in the secondary schools than ever before, yet the methods and aims are so varied that we must still call the whole movement a tendency rather than an assured triumph. Both of the constantly recurring questions in pedagogics, "What shall I teach" and "How shall I teach it," have been answered in substantially the same way by all teachers of Latin, Greek and Mathematics. In English, however, there is a wide divergence of views as to the proper answer to each. In no other department of study, perhaps, has the teacher freer play for his personality, and greater opportunity, therefore, for the display of originality, and, I may add, of eccentricity. But in education, as in government, excessive individualism is as dangerous as a mechanical uniformity. The ideal educational system is an organic whole. It may not be unprofitable, therefore, for us to consider again the much discussed question of English composition teaching.

The ideas advanced in this present paper have been put into shape after an investigation of the methods and aims in the teaching of English, especially composition, in the secondary schools of Mississippi. This investigation was made because my contact with themes written by college students had brought me to the conclusion that, since the schools were not achieving success in this line of work, there must be something wrong in the methods used. This belief led me to prepare a set of questions to be answered in writing by all Freshman students in the University of Mississippi. These questions touched upon their preparation in grammar and spelling, in composition and rhetoric, and in reading the prescribed masterpieces. I carefully read the ninety-four sets of answers, representing in all forty-two schools, and took full notes of their contents. In this way I gained an insight into school methods which could not have been gained in any other way. Though I believed that the students had answered the questions in perfect good faith, in order to make assurance doubly sure, I verified the information obtained by inquiries made of principals and teachers in the secondary schools. Hence I believe the picture I present is a just one.

Let us see what the conditions in regard to composition teaching are. The first general conclusion that would be drawn from these papers is that the schools taken collectively do not exhibit any uniformity in their English instruction; they differ widely in quantity of work done, in quality, and in their estimate of the ultimate object of instruction. The question, "How many of the prescribed English masterpieces were read in direct preparation for college?" drew forth a great diversity of answers ranging from "all read" to "none." Many said that they had read a few of the masterpieces and parts of some others. From the answers to other questions it was evident that in only a few schools was there even the most superficial connection between the literature study and the composition work. Here is an answer which gives, it seems to me, the average situation: "I read some of the required books merely for the substance and the pleasure I could get out of them, and did not make them a study, so of course they were not explained to me or discussed by me in class, and I never made them the subject of a written exercise." Another wrote: "Each work

was read entire, and special stress was given to word study and derivation and telling the figures of speech. The works were used as a subject in written exercises."

The answers to the question: "How much time was spent in your school in English composition? What was the length in words, approximately, of each written exercise?" exhibit great diversity and weakness. One student writes: "It was every day (30 m. recitation) two terms one year, and our essays were 800-1000 words." It is almost impossible to tabulate the answers to this question. For this the schools, in a great measure, are themselves responsible. They represent extremes. Some schools spread the instruction in composition over the entire course, giving a moderate amount each week. Others, again, seem to concentrate all the composition work into one year. But of all the schools, except a very few, it would be perfectly safe to say that the aggregate amount of work is quite inadequate. The general rule seems to be that the difficult art of writing the mother tongue is to be taught by having perhaps only one hour each week devoted to it, and by requiring pupils, once every month or two, to perform the drudgery of writing a long 1000-word "composition."

The answers to the question "Did you study any text-book of rhetoric? What was the nature of the instruction?" were confusing. Very many students answered as if rhetoric was an entirely distinct subject from composition, something to be studied on its own merits without regard to their writing. This conception is inevitable, one may say, in a school that disposes of rhetoric in a term or two by recitation only or mainly.

Some remarkable answers were given to a question about the kinds of subjects on which students had been required to write. Thus one writes: "Subjects were usually given us by the teacher; e. g., 'Bees,' 'Character,' 'Napoleon Bonaparte,' 'Mountains,' 'The Last Time I Went Fishing,' 'How I Spent My Vacation.'" Another says: "Our subjects were chiefly argumentative, or on some current topic of interest: 'Temperance vs. Total Abstinence,' 'Canada should be annexed,' 'Our War with Spain,' 'Fairies,' 'Rats,' etc." I do not believe the answer was intended for an anti-climax.

To the last question asked: "State any other facts that may aid in forming an estimate of the work actually done in English in preparatory schools. How much time and attention did English receive in comparison with other subjects? Were your written exercises or examination papers in mathematics, Latin, history, etc., corrected for faults of spelling and expression?" the answers were in the main not clear. Evidently not many of the writers were accustomed to summing up the operation of a study running through more than one year, and their memories failed them. The inability betrays, I think, a defect in the training itself. The same writers would have done better if asked to recapitulate their course in Latin or mathematics. The answers to the second part of the question: "How much time and attention did English receive in comparison with other subjects?" were in three groups. One group maintained that English received fully as much attention as any other study and justified the assertion by the superior quality of the papers. Another group took the same ground but denied the assertion by writing extremely poor papers. The third group, the great majority of the class, were either noncommittal or inclined to the view that English did not get an equal share of attention.

To the last part of the foregoing question: "Were your written

exercises or examination papers in other studies corrected for faults of spelling or expression?" very few gave satisfactory answers. Many gave no answer at all. Some stated that occasionally a fault in spelling (but not in expression) had been corrected in such written exercises. Only a very few were able to give the assurance that their general school work had been thoroughly corrected for poor English. Such are some of the facts.

One general conclusion, I think, must be drawn from these papers. Or rather, one general conviction forces itself upon the reader. It is that the work in English composition is not giving satisfactory results. What is the remedy for the failure on the part of the secondary schools in this respect? The schools have the remedy in their hands, but many of them fail to see it because, like most genuine remedies, it is very simple. Perhaps it has been overlooked or misapprehended precisely because it is so simple. Were it more complex or more mysterious, it might succeed better in commanding regard. The remedy consists, to put it into a short phrase, *in changing school English from a study into an art.* The teachers of composition have forgotten the commandment: "Thou shalt always hold practice primary in thy teaching of composition; theory thou shalt regard as only secondary." This, broadly speaking, is the cause of the failure, so far as it may be called a failure, in teaching composition. For convenience in applying the remedy, we may, in our diagnosis, attribute the ailment to three causes: 1, The essays required are too infrequent and too long; 2, the distinctive function of composition work is not regarded; 3, the printed page is not made the supreme teacher of composition. Taking up these reasons in the order of their statement let us attempt to make some suggestions by which matters may be improved. I am sure that no true teacher in Mississippi would deny that the only royal road to success in composition is to practice writing, and I am equally sure that many teachers yearn to follow this method in their schools. But they are handicapped by difficulties of several kinds, two of which, at least, will at once suggest themselves: 1, The pupil does not have time or inclination to write as many compositions as his teacher knows he ought to write; and, 2, the teacher does not feel that he has time to correct as many exercises as the pupils ought to write. Yes, English composition is one of the bugbears of teachers and pupils alike. The pupils find talking so much easier than writing that the latter seems a wanton retardation of utterance; while the teacher inwardly sighs as he sees the composition papers piling up and reflects on the unmitigated tedium of correction that is in store for him. Indeed, many a teacher wears himself out correcting papers and is nevertheless forced to look back over the work of the session with feelings far from complacent. And yet, no faithful and observant teacher can doubt that pupils learn to write only by writing; and that it is the duty of the teacher to correct rigidly every written page that the pupil submits. The difficulty in the whole matter, I think, lies in the fact that the compositions demanded are not too many, but too long. We expect the pupil to write a composition as soon as he has learned to write a sentence. In other words, we try to pass from the sentence to the composition, making the sentence the unit of composition. The unit of composition (a composition being a structural aggregate) is the paragraph. We should pass, therefore, from the sentence to the paragraph, then to the composition proper. Drill the pupil in the paragraph, which is nothing more than a

cluster of sentences dealing with a single topic. Let the paragraphs be short, not more than ten or fifteen lines at first, but see that they have unity and symmetry. Spend months on this; for the paragraph is the composition in miniature.

In other words subdivide your topics into small parts and drill on each separately. Let me illustrate. Suppose you desire a composition on "A Day's Hunt." Let the pupils write separate paragraphs on: 1. How I Longed for the Day to Come; 2. The Start; 3. My Companions; 4. Our Dogs; 5. The First Game; 6. A Bad Shot; 7. A Shower; 8. Our Lunch; 9. An Accident; 10. Something Funny; 11. What We Killed; 12. Our Return.

Now if these paragraphs or miniature compositions are short, the teacher can correct them not only with less expenditure of time but with more efficiency than if four or five pages had been written. After a drill in this way, assign the entire topic, "A Day's Hunt."

Great difficulty is sometimes found in securing and assigning appropriate topics. The difficulty chiefly arises from failure to remember the distinctive function of composition teaching. The aim is not to give the pupil information on the topics chosen, but to teach him how to arrange and present the information already in his possession. I am speaking always of secondary work, not of the collegiate period when the student may sometimes fairly be expected to "work up" a given subject. Topics, therefore, about which the student is ignorant should not be assigned, even though the source of information be ready at hand. Exercises in composition should not be intended to teach new facts, but to teach how to systematize and present facts already known. The difference is that between gathering flowers and arranging them into bouquets. The pupil is supposed to be culling from every book that he studies, to say nothing of the wider fields of experience and observation; but work in composition has as its distinctive function the orderly arrangement and expression of thought won from any field whatsoever. I emphasize this because I believe that just in proportion as the pupil has to collect information upon his topic to that degree he expends the time and thought that should have been put upon arrangement and expression.

I have said that composition differs from other subjects in that it deals not with amassing information, but with presenting it. Let me mention one other distinction, which is at the same time an advantage, which gives the teachers of English composition finer opportunity than the teachers of any other department have. It is this: every page of print that the pupil reads, every book that he studies, may be made to contribute to the correctness of his style. Whether it be arithmetic, geography, history, or botany, if he has inculcated in him the habit of close scrutiny of the written page, he is daily absorbing the principles of spelling, capitalization, punctuation, sentence structure, and paragraphing. This gives the teacher of English an incalculable advantage, due solely to the fact that all the information that the text-books yield must reach the pupil through the medium of written English.

This consideration, therefore, should largely control the teacher's method of dealing with composition work. He should strive to develop in the pupil, at the earliest possible stage, the habit of close observation of what he reads. The problem is to establish such a relation between the pupil and the written page that every book read shall contribute to his

knowledge of correct form. I make a plea for a more fundamental use of literature in composition teaching than the connection ordinarily made now between the two—the mere drawing of subjects for compositions from the books read. Just as the mineralogist sets an assortment of minerals before his pupils to be analyzed, or the botanist hands them a flower, saying "Examine minutely and report;" so the teacher of elementary English should insist that the pupil *scrutinize* what he reads. The printed page should be to the student of English composition what the mineral is to the student of mineralogy, what the flower is to the student of botany, what the map is to the student of geography, what the insect is to the student of entomology.

If the pupil leaves your schoolroom without having acquired the priceless habit of observation, then you have failed to avail yourself of the distinctive advantage already mentioned; you have failed to make his knowledge of good writing self-sustaining. He may read hundreds of good books without adding appreciably to his store of form, of expression, of correctness in all the details of written English because you have never put him in touch with books as the supreme teachers of composition.

How may we best accomplish this? By selecting topics, whenever possible, from the books that your pupils are using; and by selecting chiefly with the end in view of focusing the pupil's attention upon the spelling, punctuation, paragraphing, and general structure of what he is reading. But before doing this, I have found it of great benefit to have the pupil do no little copying. I do not believe that twenty-five per cent of the students in the freshman classes of our colleges can sit down to a page of conversational English and copy rapidly without error. It demands an eye open to everything on the page; it inculcates, if kept up, habits of scrutiny that will serve the pupil in every department of effort; above all it tends to make him depend for correctness more on observation and less on memorized rules; it develops the inductive sense and leads the pupil gradually to see that the rules of correctness in writing are nothing more than attempts to formulate into a system the uniform practice of good writers; and, lastly, it makes the pupil's skill in composition grow as a rolling snowball grows,—by attaching to itself what it comes in contact with.

No study of formal grammar, no acquaintance with rules or text-books, can take the place of constant scrutiny on the pupil's part of what he reads. Indeed, until the habit of close observation has been established, books on composition amount practically to nothing.

Perhaps you may ask, "Will not this unremitting attention to details that are merely formal and external divert the pupils' minds from literary beauty? By no means. You must keep it up until it becomes a second nature to the pupils, until it ceases to be an effort; just as walking, skating, dancing soon cease to be the awkward displays that they at first were. Surely Benjamin Franklin's style was not injured, nor was his literary sense dulled by his technical knowledge of type-setting and proof-reading. Shakespeare was not a worse dramatic writer because he was an actor and knew all the formal details of his craft. Whatever awkwardness may appear at first will pass away as soon as this attention to the minutiæ of composition shall have become an ingrained habit. Besides, in insisting that your pupils use their own eyes and make the attempt to formulate their own principles of expression, you are teach-

ing English composition exactly as all scientific branches are taught today. If there is one tendency in pedagogy that cannot be mistaken by even the most casual observer of methods, it is the tendency toward having the pupils learn at first hand. There are too many *media* interposed between the learner and the thing to be learned. The old way was to lead the pupil all around a topic, but rarely, if ever, to let him put his hands on it. Modern methods demand that he get a hand grip on it at once, and then circle around it to his heart's content.

Let me return, by way of conclusion, to the subject of topics. After a drill in mere copying, assign topics from some literary masterpiece that your pupils are reading. If, for example, it be "Rip Van Winkle," I should have them ascertain and write down in their own words the subject of each paragraph in the story. I should then assign, with books closed, one of these paragraph subjects as the topic for an exercise in reproduction. Keep this up, day by day, until every important paragraph shall have been reproduced in their own words. Then take the leading characters: Rip, his wife, his son, and Nicholas Vedder. Assign these in like manner as paragraph topics. Such exercises soon beget in the pupil the habit of minute observation, not only of the features of the story, but equally of the general details that constitute correct writing. His vocabulary will almost insensibly be enlarged. The certainty that he will have to reproduce in writing what he is reading will soon implant the habit of scrutiny; and when this is done the pupil is on the road to assured mastery in English composition.

It is needless to say that I do not advocate holding the pupil back in his reading of English literature until every masterpiece shall have been treated in this way. I except, also, poetry from the material proper for drill in composition. Select only prose, and the simplest prose possible. Irving, by the way, is far from being the best writer for reproduction exercises. In a word, I am not presuming to dictate authors, topics or method; but I do urge you, fellow teachers, to lay supreme emphasis on the development of the pupil's own powers of observation, remembering that these are just the powers that are now most active. Select any method that will lead to this goal, but keep this goal always in sight.

MATHEMATICAL SECTION

Some Recent Discussion of the Teaching of Mathematics

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I was led to select this topic for this afternoon by the fact that at the Glasgow meeting—held last year—of the British Association for the Advancement of Science, the section on mathematics and physics and the newly organized section on education had a joint session at which the principal paper was read by Professor John Perry of the Royal College of Science, London. This paper, as was intended, provoked a good deal of

discussion, which was followed by the appointment of a representative committee with Professor Forsyth of the University of Cambridge as chairman, "to report upon improvements that might be effected in the teaching of mathematics, in the first instance in the teaching of elementary mathematics, and upon such means as they think likely to effect such improvements." Professor Perry's paper was published in the *School World* for October, 1901, and the accompanying syllabus in the November number of the same journal. Later Professor Perry edited a book of one hundred pages, published by the Macmillan Co., containing his address, syllabus, reports of the discussion, together with written remarks from fourteen mathematicians and teachers of prominence who were not present at the meeting, and a reply by himself. I may add that the address was given in full in the *Educational Review* for February, 1902.

This discussion of the teaching of mathematics in England particularly with regard to the retention of Euclid as a text-book of geometry is by no means a new one. De Morgan, one of the best teachers of mathematics England ever had, in his article on "Mathematics" in the Penny Cyclopedia, and in substance in other places, says: "The work of Euclid is preferable in our opinion to any system which has been proposed to supply its place: simply because the dependence of conclusions upon premises is more distinct than in any other geometrical writing. The defects with which it abounds (and DeMorgan was both logician and mathematician enough fully to appreciate them) are trifles which can be remedied as they are met with; and though there are seldom three propositions together, one or other of which will not call for some remark from the teacher, yet such is Euclid that these very faults properly noted, are of more value than the greater elegance and more artificial process of less formally vigorous writers." On the contrary, Sylvester, whose enthusiasm bred contagion wherever he taught, whether in England or America, in words often quoted from his presidential address to the mathematical and physical section of the British Association in 1869, says: "I should rejoice to see mathematics taught with that life and animation which the presence and example of her young and buoyant sister (natural and experimental science) could not fail to impart, short roads preferred to long ones, Euclid honorably shelved or buried 'deeper than ever plummet sounded,' out of the school boy's reach, morphology introduced into the elements of algebra—projection, correlation and motion accepted as aids to geometry—the mind of the student quickened and elevated and his faith awakened by early initiation into the ruling ideas of polarity, continuity, infinity, and familiarization with the doctrine of the imaginary and the inconceivable." He confesses: "The early study of Euclid made me a hater of geometry . . . and yet in spite of this repugnance, which had become a second nature in me, whenever I went far enough into any mathematical question I found I touched at last a geometrical bottom." Again, Todhunter, the teacher, examiner and English mathematical text-book writer *par excellence*, in a 56-page essay on Elementary Geometry, wields the cudgels most vigorously in favor of a strict adherence to Euclid. He suggests that the grounds of Sylvester's dislike may have been "only the repugnance which might naturally be felt by a creative mind conscious of the power to advance without any superfluous aid," and says: "Tradition seems to record such characteristics of Newton and Pascal. It would be unwise, however, to suppose that such exceptional cases are likely to be common."

The opposition to Euclid in England seems first to have taken definite form in the organization in the year 1871 of the Association for the Improvement of Geometrical Teaching, whose object, as stated in the Code of Rules, "shall be to effect improvements in the teaching of elementary mathematics and mathematical physics, and especially of geometry." This association has published a syllabus of plane geometry, a syllabus of modern geometry, and a text-book entitled Elements of Plane Geometry; but by reason of the undisguised hostility of various boards of examiners, it has accomplished comparatively little. The present revival of the discussion is due to the untiring activity and zeal of Professor John Perry, whose charming naiveté is not concealed even in his text-book on the calculus. For twenty-odd years, in season and out of season, with reason, and sometimes, I fear, without reason, he has preached on "England's Neglect of Science," "The Defects in the Teaching of Mathematics," and similar subjects, till finally he secured a hearing before the two sections of the British Association in September, 1901. As early as July he notified those who were expected to take part in the discussion, of the date assigned for the reading of his paper, September 16, and had copies of his paper printed for distribution before the meeting; but a change to a date three days earlier was found imperative, so that some of the expected speakers did not reach Glasgow in time, while those who were present did not have the wished-for opportunity carefully to examine the paper before the discussion. Still the written remarks from various contributors now published with the address, render this change of slight consequence.

Professor Perry was very much in earnest. He begged his auditors to give him the benefit of their severest criticism and advice, and said: "Anybody who thinks I am making a mistake, or who sees how my method may be improved, and who holds his tongue, is doing a real harm to the country." As would be expected from a teacher in a technical college, Professor Perry is a staunch believer in the utility of mathematics. The obvious forms of usefulness in the study of mathematics he enumerates as follows:

"1. In producing the higher emotions and giving mental pleasure. Hitherto neglected in teaching almost all boys.

2. (*a*) In brain development. (*b*) In producing logical ways of thinking. Hitherto neglected in teaching most boys.

3. In the aid given by mathematical weapons in the study of physical science. Hitherto neglected in teaching almost all boys.

4. In passing examinations. The only form that has not been neglected. The only form really recognized by teachers.

5. In giving men mental tools as easy to use as their legs or arms, enabling them to go on with their education (development of their souls and brains) throughout their lives, utilizing for this purpose all their experience. This is exactly analogous with the power to educate one's self through the fondness for reading.

6. Perhaps included in (5): in teaching a man the importance of thinking things out for himself and so delivering him from the present dreadful yoke of authority, and convincing him that whether he obeys or commands others, he is one of the highest of beings. This is usually left to other than mathematical studies.

7. In making men in any profession of applied science feel that they

know the principles on which it is based and according to which it is being developed.

8. In giving to acute philosophical minds a logical counsel of perfection altogether charming and satisfying, and so preventing their attempting to develop any philosophical subject from the purely abstract point of view, because the absurdity of such an attempt has become obvious."

He believes most sincerely that these desirable functions would be performed well under the new system which is suggested. It may be well to quote a characteristic passage: "The ancients devoted a lifetime to the study of arithmetic; it required days to extract a square root or to multiply two numbers together. Is there any great harm in skipping all that, in letting a boy learn multiplication sums, and in starting his most abstract reasoning at a more advanced point? Where would be the harm in letting a boy assume the truth of many propositions of the first four books of Euclid, letting him accept their truth partly by faith, partly by trial? Giving him the whole fifth book of Euclid by simple algebra? Letting him assume the sixth book to be axiomatic? Letting him, in fact, begin his severer studies where he is now in the habit of leaving off? We do much less orthodox things. Every here and there in one's mathematical studies one makes exceedingly large assumptions, because the methodical study would be ridiculous even in the eyes of the most pedantic of teachers. I can imagine a whole year devoted to the philosophical study of many things that a student now takes in his stride without trouble. The present method of training the mind of a mathematical teacher causes it to strain at gnats and to swallow camels. Such gnats are most of the propositions of the sixth book of Euclid; propositions generally about incommensurables; the use of arithmetic in geometry; the parallelogram of forces, etc.; decimals. The camels I do not care to mention because I am in favor of their being swallowed, and indeed I should like to see them greatly increased in number; these exist in the simplest arithmetic, and geometry and algebra. Why not put aside ever so much more, so as to let a young boy get quickly to the solution of partial differential equations and other useful parts of mathematics that only a few men now ever reach? I have no right to dictate in these matters to the pure mathematicians. They may see more clearly than I do the necessity of a great mathematician going through the whole grind in the orthodox way; but, if so, I hardly see their position in regard to arithmetic and other things in the study of which they do allow skipping. I should have thought that the advantage of knowing how to use spherical harmonics or Bessel functions at the age of seventeen, so as to be able to start in mathematics at Cambridge just about the place where some of the best mathematical men now end their studies forever, of starting at this high level with youthful enthusiasm, and individuality, and inventiveness, would more than compensate for the evils of skipping."

The first part of the syllabus, and the only part we shall take up, is entitled "A Course of Elementary Mathematics. A course of study recommended for training colleges and for boys and girls."

"*Arithmetic.*—Decimals to be used from the beginning; the fallacy of retaining more figures than are justifiable in calculations involving numbers which represent observed or measured quantities. Contracted and approximate methods of multiplying and dividing numbers whereby all unnecessary figures may be omitted. Using rough checks in arithmetical

work, especially with regard to the position of the decimal point.

The use of 5.204×10^5 for 520400, and of 5.204×10^{-3} for .005204. The meaning of a common logarithm; the use of logarithms in making calculations involving multiplication, division, involution and evolution; calculation of numerical values from all sorts of formulæ however complex.

The principle underlying the construction and method of using a common slide rule; the use of a slide rule in making calculations. Conversion of common logarithms into Napierian logarithms. The calculation of square roots by the ordinary arithmetical method. Using algebraic formulæ in working questions in ratio and variation. Simplification of fractions. Calculation of percentages, etc.

Algebra.—To understand any formula so as to be able to use it if numerical values are given for the various quantities. Rules of indices. Being told in words how to deal arithmetically with a quantity, to be able to state the matter algebraically. . . . Problems leading to easy equations in one or two unknowns. Easy transformations and simplifications of formulæ, and in easy cases finding any one of several quantities in a formula when the others are given. . . . The determination of the numerical values of constants in equations of known form when particular values of the variables are given. The meaning of the expression 'A varies as B.' Factors of such expressions as x^2-a^2, $x^2-11x+30$, $x^2-5x-66$."

From the paragraph on mensuration I can quote only a few statements, showing how Professor Perry would use experimental methods to test the accuracy of rules. Thus, "Testing experimentally the rule for the length of the circumference by using strings round cylinders, or by rolling a disc or sphere. Inventing methods of measuring the lengths of curves. Testing rules for the areas of a triangle, parallelogram, etc., by use of scales and squared paper." The determination of the areas of irregular plane figures by five different methods, including the use of Simpson's rule and the planimeter. . . . "Rules for volumes of prisms, cylinders, cones, spheres and rings, verified by actual experiment; for example, by filling vessels with water or by weighing objects of these shapes made of material of known density, or by allowing such objects to cause water to overflow from a vessel. . . . Stating a mensuration rule as an algebraic formula, etc."

"*Use of Squared Paper.*—The use of squared paper by merchants and others to show at a glance the rise and fall of prices, of temperature, of the tide, etc. The use of squared paper should be illustrated by the working of many kinds of exercises, but it should be pointed out that there is a general idea underlying them all." Among others he mentions such as the following: "Plotting of statistics of any kind whatsoever, of general or special interest. What such curves teach. Rates of increase.

Interpolation. . . . Probable errors of observation. The calculation of a table of logarithms. Finding an average value. The method of fixing the position of a point in a plane. Plotting of functions, such as $y=ax^n$, $y=ae^{bx}$, for various values of a, b, and n. The straight line, meaning of its slope, slope of a curve at any point in it.

Determination of maximum and minimum values. The solution of equations."

"*Geometry.*—Dividing lines into parts in given proportions, and other experimental illustrations of the sixth book of Euclid. Measurements of angles in degrees and radians. The definitions of the sine, cosine and tan-

gent of an angle; determination of their values by graphical methods; setting out of angles by means of a protractor when they are given in degrees or radians, also when the value of the sine, cosine or tangent is given. Use of tables of sines, cosines and tangents. The solution of a right-angled triangle by calculation and by drawing to scale. The construction of a triangle from any given data; determination of the area of a triangle. The more important propositions of Euclid may be illustrated by actual drawing; if the proposition is about angles, these may be measured by means of a protractor; or if it refers to the equality of lines, areas or ratios, lengths may be measured by a scale, and the necessary calculations made arithmetically. This combination of drawing and arithmetical calculation may be freely used to illustrate the truth of a proposition. A good teacher will occasionally introduce demonstrative proof as well as mere measurement." Then follow some elementary uses of analytic geometry of space and descriptive geometry.

In the very interesting discussion which followed the reading of the paper and the presentation of the syllabus decided objection was made to the strongly utilitarian tendency of a large part of Professor Perry's remarks. Professor Forsyth, in particular, said: "I must point out what would be a platitude if we were not in discussion, that scientific subjects do not progress necessarily on the lines of direct usefulness. Very many of the applications of the theories of pure mathematics have come many years, sometimes centuries, after the actual discoveries themselves. The weapons were at hand, but the men were not ready to use them. Take the case of medicine, which surely is a practical subject. It owes immense debts to the study of sciences like physiology and bacteriology; yet these have been developed and continue to be developed, along their own lines, without being guided in the direction of immediate application at every turn. Yet independent as has been their development, it is notorious that, perhaps all the more because of their freedom in growth, they have provided new knowledge that is of the utmost importance in the conduct of living processes. Take one last example, the X rays. If any one had been set down, as a practical problem, to take a photograph through solid things, I think the common answer would have been that he was being told to solve an insoluble problem. Yet its solution came from the physicists, indirectly as it were, in the course of researches made to obtain knowledge for its own sake. The knowledge so obtained has subsequently led to wonderful results in its application. Influenced by these examples and by others more directly mathematical upon which I shall not enter, I must decline to accept utility as the main or the sole discriminating test, either in the study or the teaching of mathematics."

Had I the time I should like to quote from the remarks of several of the other participants, but I shall have to content myself with a few selections.

Lord Kelvin wrote: "I am overdone with work which must not be postponed, and I am sorry therefore not to be able to write anything on the subject. I think your syllabus was good indeed. It is very like the teaching I had from my father."

Sir John Gorst, chairman of the joint session, told a unique experience he had in New Zealand in his younger days. He said: "I taught, or attempted to teach, mathematics to the Maori boys and men. As far as the teaching of arithmetic went I taught on a sort of embryo Sonnenschein

principle, and I found them remarkably apt and quick pupils. They learned the practical arithmetic, which was useful to them in actual life, and they learned it with extraordinary rapidity— far faster than boys or men would generally learn it in this country. But when in my youthful enthusiasm I proceeded to try to teach some of them Euclid, or rather geometry after the Euclid fashion, I absolutely and entirely failed. There was not one of them that could grasp or understand the simplest of the propositions of Euclid. . . Had I had the advantage of the discussion to which I have listened to-day, I should have abandoned teaching in the ordinary way until they had been familiarized with angles, lines, areas, and geometrical figures, of which the Maori youth was absolutely ignorant. I suppose by a method of that kind even the least developed intellect of the uncivilized native of New Zealand might have been brought to take in some of the very simple propositions of geometry."

Professor Everett said: "The teaching of geometry has been too prosaic. The minds of boys and girls are not ripe for dealing with abstractions. The way in which Euclid begins (especially if the whole body of definitions is taken first) gives the learner the impression of a castle in the clouds.

A moderate amount of practical geometry should come first, including methods of bisecting angles and lines, drawing lines at right angles, making a triangle with sides of prescribed lengths, and inscribing a regular hexagon in a given circle. This will give the learner definite conceptions, and help him to feel that he is on solid ground.

Side by side with Euclid, or a substitute for Euclid, verification by actual measurement of carefully drawn figures should be encouraged. It is useful as a test of the accuracy with which measurements can be made by the methods employed, and also useful as a check against mistakes—which are liable to be made in abstract reasoning as well as in other matters. One of the most important habits in scientific investigation of all kinds is the habit of testing the correctness of one's conclusions by independent methods; and this habit should be inculcated by assiduous practice, as an important element in personal character—an element inseparably associated with the honest pursuit of truth. . . .

The learner should be taken on, as quickly as is consistent with intelligent progress, to the higher branches of mathematics. . . .

The elementary conceptions of the infinitesimal calculus and its simpler processes, should be introduced at an early stage in mathematical teaching.

Another subject that is too long postponed is solid geometry. It is postponed so long that most boys do not get it at all. Considering that we live and move in space of three dimensions, it is unreasonable and impractical to confine all accurate thinking and teaching for three or four years to two-dimensional space. The result is to produce an instinctive shrinking from three-dimensional thinking, as if it involved some terrible mystery." I wonder what Professor Everett would think of the method now coming into vogue in Italy of teaching plane and solid geometry together from the beginning! Professor Everett's remarks are so good throughout that I should like to quote further, but time will not permit. I will hasten on to Professor Perry's summing up of the discussion. He says: "We who have taken part in this discussion have been criticized by some educationists because we have only been expressing well-known educational truths. They forget that, however well-known these truths

may be, they have never yet—never till now—been expressed publicly by more than two or three mathematical teachers. They forget that a reform in the teaching of mathematics was absolutely impossible without the consent and advice of the mathematicians.

It will be found that my syllabus contains almost all the new suggestions which were made by speakers who had no time to study it. (1) Experimental geometry to precede demonstrative. (2) Some deductive reasoning to accompany experimental geometry. (3) Mathematics to enter into the experimental science syllabus as much as possible. (4) Rough guessing at lengths. weights, etc., to be encouraged. (5) Recognition of the incompleteness of any external examination. (6) The importance of familiarizing a boy with problems in three-dimensional space. (7) A hard and fast syllabus undesirable; even the sequence of subjects to be left to a good teacher's initiative.

Further on Professor Perry rather nonchalantly says: "On the whole, I think it may be said that I am in accord with every one of my critics, but of course I know that they cannot unreservedly agree to the adoption of my syllabus as it stands for every kind of student. At all events it is quite evident that there is unanimity in the desire for an immediate large reform in the teaching of mathematics.

I have long known that there is this unanimity among educationists generally, but it is unexpected to find it among the great mathematicians, and the most important teachers of mathematics. I take it that we are all agreed upon the following points:—

1. Experimental methods in mensuration and geometry ought to precede demonstrative geometry, but even in the earliest stages some deductive reasoning ought to be introduced.

2. The experimental methods adopted may greatly be left to the judgment of the teachers; they may include all those mentioned in the elementary syllabus which I presented.

Some of the things for which I contend were put so prominently forward that, if speakers did not object to them specifically, they may almost be taken as agreed to. They are such things as these that follow. Most of them are agreed to specifically by about half my critics.

3. Decimals ought to be used in arithmetic from the beginning.

4. The numerical evaluation of complex mathematical expressions may be taken up almost as part of arithmetic, or at the beginning of the study of algebra, as it is useful in familiarizing boys with the meaning of mathematical symbols.

5. Logarithms may be used in numerical calculation as soon as a boy knows that $a^n \times a^m = a^{n+m}$, and long before he is able to calculate logarithms. But a boy ought to have a clear notion of what is meant by the logarithm of a number.

6. In mathematical teaching, a thoughtful teacher may be encouraged to distinguish what is essential for education in the sequence which he employs, from what is merely according to arbitrary fashion, and to endeavor to find out what sequence is best, educationally, for the particular kind of boy whom he has to teach.

7. Examination cannot be done away with in England. Great thoughtfulness and experience are necessary qualifications for an external examiner. It ought to be understood that an examination of a good teacher's

pupils by any other examiner than the teacher himself is an imperfect examination.

I have not much doubt as to the unanimity with which everybody may be said to have agreed explicitly or implicitly to all the above statements. About these that follow I am in more doubt. More than half my critics will, I believe, agree to them all for all students. I think that every one of my critics will agree to allow a judicious teacher a free hand, especially when he knows that his pupils are likely to need the use of mathematics in their other studies, and especially if they are likely to become engineers, —i. e., men who apply the principles of natural science in their daily work.

8. A thoughtful teacher ought to know that by the use of squared paper and easy algebra, by illustrations from dynamics and laboratory experiments, it is possible to give to young boys the notions underlying the methods of the Infinitesimal Calculus.

9. A thoughtful teacher may freely use the ideas and symbolism of the calculus in teaching elementary mechanics to students.

10. A thoughtful teacher may allow boys to begin the formal study of the calculus before he has taken advanced algebra or advanced trigonometry, or the formal study of analytical or geometrical conics, and ought to be encouraged to use in this study not merely geometrical illustrations, but illustrations from mechanics and physics, and illustrations from any other quantitative study in which a boy may be engaged."

Since Professor Perry's report was published the discussion has gone merrily on. By invitation of a member of the British Association committee some twenty-two teachers in prominent English public schools sent in a sketch of the changes they would like to see made. In the treatment of geometry they are of opinion:—

"1. That the subject should be made arithmetical and practical by the constant use of instruments for drawing and measuring.

2. That a substantial course of such experimental work should precede any attack upon Euclid's text.

3. That a considerable number of Euclid's propositions should be omitted, and in particular

4. That the second book should be treated slightly and postponed till III, 35 is reached.

5. That Euclid's treatment of proportion is unsuitable for elementary work."

As to arithmetic, they think it "might well be simplified by the abolition of a good many rules which are given in text-books. Elaborate exercises in vulgar fractions are of doubtful utility; the same amount of time given to the use of decimals would be better spent. . . . Four-figure logarithms should be explained and used as soon as possible. It is generally admitted that we have a duty to perform towards the metric system. This is best discharged by providing all boys with a centimeter scale, and giving them continual exercise in verifying geometrical propositions by measurement. . . . Probably it is right to teach square root as an arithmetical rule. . . . Cube root is harder and should be postponed until it can be studied as a particular case of Horner's method of solving equations approximately."

Passing to algebra, we find that a teacher's chief difficulty is in the tendency of his pupils to use their symbols in a mechanical and unintelligent way. . . . Elementary work in algebra should be made as far as

possible arithmetical. . . . Such an exercise as the plotting of the graph $y=2x-\frac{x^2}{4}$ provides a series of useful arithmetical examples which have the advantage of being connected together in an interesting way. . . Subsequently curve tracing gives a valuable interpretation of the solutions of equations. . . . We think that undue weight is often given to such subjects as algebraic fractions and factors. . . Might not the theory of quadratics be deferred till it can be dealt with in connection with that of equations of higher degrees? . . . Indices may be treated very slightly. . . . Our recommendations in algebra are corollaries of two or three simple thoughts; the object in view being,—to discourage mechanical work; the means suggested,—to postpone the more abstract and formal topics, and, broadly speaking, to arithmeticize the whole subject."

They recommend that this be followed by a type of diluted trigonometry in which only the sine, cosine, and tangent shall be introduced with the two identities $sin\Theta^2+cos^2\Theta=1$, $tan\ \Theta=\frac{sin\Theta}{cos\Theta}$, afterward returning to formal algebra for "a revision course bringing in literal equations, irrational equations, and simultaneous quadratics illustrated by graphs, partial fractions, and binomial theorem for positive integral index."

At the annual meeting of the mathematical association held in London, January 18, a paper was presented by Professor A. Lodge on Reform in the Teaching of Mathematics. He spoke principally of the teaching of geometry, and said: "I believe we could not do better at the outset than adopt some French text-book as our model. The Americans have done so already.

The chief points in the French text-books are

1. The more orderly arrangement of propositions.
2. The entire separation of theorems from problems of construction, hypothetical constructions being used in proving a theorem.
3. The closer association of a proposition and its converse when both are true.
4. The adoption of arithmetical notions and algebraic processes.
5. The early introduction of simple loci.
6. Insistence on accurate figures drawn by accurate and practical processes.

7 Practice in exercises from the very beginning. Mr. Greenstreet suggests that I should also add:

8. Attention paid to the various phases of a theorem as the figure changes, and (as the student progresses) to the easier forms of generalization.

"The greater part of these improvements could be adopted at once, provided the sanction of the great examining bodies can be obtained." Aye, but there's the rub.

The *School World* for March is a special mathematical number. It contains articles on school mathematics from the university point of view by mathematicians of Oxford, Cambridge and Glasgow, an article on Elementary Trigonometry in Schools, by Professor Mathews; a Review of the British Association Discussion, by Professor Bryan; a paper on the Teaching of Secondary Mathematics, by Professor Minchin; one on the Teaching of Euclid's Elements, by Headmaster Fletcher, together with considerable correspondence. I shall make a few selections from Professor Bryan's review. He says:—

"It may now be taken for granted that some important changes are at the present time desirable in the order of learning mathematics in this country (for I regret to find that so much is being said about teaching and so little about learning), but it is greatly to be feared that, soon after a change has been made, the new system will be found to have its own drawbacks no less than the old. . . .

In the old style of things the use of algebraic symbols was prohibited in examinations in Euclid. Is it not the fact that much greater life and reality can be put into the study of geometry by encouraging instead of excluding the use of algebraic formulæ?"

After giving illustrations he goes on to say:—

"This use of algebra in the study of geometry has the following advantages:—

1. It breaks down the hard and fast line between algebra and geometry.

2. It furnishes the student with a number of easy examples and exercises in geometry. . . .

3. It introduces the beginner in algebra to the use of symbols for representing concrete quantities (lengths, angles, etc.) and to the nature and meaning of an algebraic formula. . . .

. . . Formal blackboard lectures are a very ineffectual means of teaching improved methods to a beginner. Besides being wasteful of time they require him, (i) to listen when the teacher is talking, (ii) to look at the blackboard when he happens not to stand in front of it, (iii) to write down notes of the lectures and (iv) to think of the method of reasoning, all at the same time, and if he fails for a moment to perform simultaneously any one of these four operations he loses the whole thread of the lecture. Hence it is that so many pupils after the most 'thoughtful' lecturing reproduce faulty text-book proofs which they have been warned against by their teachers, but which they can at least 'get up'."

He sums up as follows:—

"The teacher can do very little to reform the teaching of mathematics to large classes of elementary pupils, for, if he departs materially from the methods of the text-books, the learning of mathematics will suffer accordingly.

The text-book writer can do practically nothing to reform the teaching of mathematics, otherwise his books will not sell and other books will be used instead. This is particularly true when faulty methods or inaccurate statements have to be reproduced (as is frequently the case) in order to make a book salable.

The examiner can do much to reform mathematical teaching by modifying the character of his questions so far as this is consistent with his syllabus, and with giving candidates a fair chance of scoring marks.

The governors of educational institutions could greatly reform mathematical teaching by increasing the mathematical teaching staffs and giving mathematics a more prominent place in the curriculum. This must come about sooner or later, and the sooner the better.

There is no royal road to teaching mathematics, for it is impossible for a boy of given capacity to learn more than a certain amount in a certain time, the rate of learning varying with the individual, from zero upwards, and if it be attempted to introduce new ideas too rapidly into the course the result must be a hopeless failure."

The frank confessions and the suggestions for improvement—which we

must assume to be equally honest—found in these discussions throw an unmistakable flood of light upon the mathematical situation in the public schools of England. Held in servitude by the boards of examiners, who will not permit a hair's breadth variation from the order of Euclid's elements, and required to submit to external examinations which serve principally to reveal the malevolent ingenuity of framers of impractical problems, both teachers and pupils groan under a worse than Egyptian bondage. Small wonder that elementary mathematical teaching in England has fallen so far below that of France, Germany, Italy or America!

The probable outcome of this discussion is hard to forecast. That the committee will recommend some substantial changes for the better may reasonably be expected. That it will advise the rejection of Euclid as a text-book is by no means certain, though it would seem as if nothing pedagogically worse than the present teaching of Euclid, without any knowledge of concrete geometry, or any use of rule, compasses, and protractor, could easily be devised.

The process of change, even when once begun, will need at least a generation. Boards of examiners must "put away the evils of their doing from before all eyes and learn to do well."

Teachers will have to be trained by some other method than merely putting new wine into old bottles, and possibly the author in his anguish will be compelled to say, "Oh, that mine adversary had written a book!"

Methods of Attack in Geometry

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Geometry has long been looked upon as furnishing a peculiar and distinct kind of mental discipline. Plato inscribed above the entrance to his school, "Let no one unacquainted with geometry enter here." Today if we are asked why the subject is taught in our high schools we say that aside from the fact that a certain knowledge of geometry, as that concerning areas and volumes, is useful and should be known, it is given largely because it furnishes almost the only examples of pure logic in the high school course, that it teaches the student to consider carefully given data, and to reason from this to accurate conclusions; yet whether the student can do this or not depends largely upon how the subject is taught. If a student of geometry be given an exercise that does not involve familiar figures and theorems, although it may be a theorem in some other branch of mathematics, he is usually helpless in discovering a key to the proof. This shows us how much of what we thought in the geometry class was the result of reason must have been the result of a good memory. Suppose he is given the theorem that "all prime numbers are either of the form $6n+1$ or $6n-1$." If he gets a proof at all, there is generally a lack of definite, systematic method of attacking it, and one is convinced that he is *not* being taught "to consider carefully given data and reason from this to accurate conclusions" to the extent that we might expect. I find that only a small per cent of those who come to us—a great many of whom are from the smaller high schools perhaps—are able to attack with any degree of elegance or satisfaction such theorems as the above.

Geometry can certainly be so taught as to secure to a very satisfactory degree the desired culture value spoken of above, but I fear that too often we are satisfied if the student of geometry can reproduce the book on the blackboard or on paper and possibly be able to justify each statement of the text by citing some previously studied proposition, axiom, or definition. The statement that one often hears in a geometry class that "I can't remember how it begins," "I forget the next step," or "I don't remember the proposition but I know how to prove it," leads me to believe that with far too many pupils and in too many class rooms the subject is more a drill in memory than an exercise in logic. Granting, however, that the student does see every step in the proof, and sees in the proof an example of logical deductive reasoning, the method of proof in our texts is necessarily synthetic, with no hint as to how the proof was discovered or what suggested the theorem; hence the study of the demonstrated theorems cannot of itself give the student the power to solve or prove the various propositions that will present themselves in other subjects. To get the greatest educational good from the subject the student must not be hurried through the course, learning simply the proofs of the text, but must supplement this by a great deal of original work in various demonstrations and solutions.

Happily the exercises (usually called originals in this country and riders in England) cannot be grouped into cases, and methods, rules, or principles given that enable us to solve all of each case as we used to do in our older arithmetics when we came to the subject of percentage, yet there are certain principles or methods of attack that make the study of an exercise systematic or scientific in the fullest measure, and unless the student is taught to study exercises in this systematic way—unless he is taught to study the exercises from the standpoint of analysis and thus discover the possible lines of procedure in attacking the demonstration—he is not gaining the power that is going to help him to study the larger problems of life. The student of geometry, when given an exercise, should no more fold his arms and try to recall "some proposition like it," or look through his or other texts for a proof than a student of botany or chemistry should determine a plant or find the ingredients of a compound by finding in his encyclopedia something that looks like it. He ought to have a definite line of procedure and be able when a proposition is proposed to do something if it is nothing but to waste paper, just as the student of chemistry would do something if nothing but have an explosion.

While but few rules can be laid down, these few give system to our work. Let us notice the general lines of procedure.

1. First, *assume that the theorem is true and draw an accurate figure*, and the accurately drawn figure will often suggest a proof; for example, certain triangles may appear to be congruent; if they are this will lead to some other relations that make the proof evident, hence we seek to prove these triangles congruent.

By assuming the theorem to be true is meant, that, if for example, certain lines or angles are to be proven equal they are to be drawn so; and drawing an accurate figure means not only that if lines are equal, parallel or perpendicular, they must be drawn so, but also that lines are *not* to be drawn equal, parallel or perpendicular unless they are given so. A triangle is not to be drawn with two sides equal unless the theorem calls for an isosceles triangle, nor a quadrilateral drawn with any two sides equal or parallel unless the exercise calls for a special quadrilateral of this kind.

An inaccurate figure may seem to show relations that do not exist, as in the examples given in "Ball's Mathematical Recreations" where all triangles are proven to be isosceles or a right angle equal to an obtuse.

2. After the figure has been drawn *get clearly in mind just what is given in the figure and just what is to be proven*, i. e., the *data* and the *conclusion*. It is also very important that *the student kuow the definition of all terms in the theorem*, and instead of the *hypothesis* and *conclusion* of the theorem it will be well to use Pascal's advice and "substitute the definition for the name of the thing defined" and thus get a *new hypothesis* and *a new conclusion.*

3. Next, *recall all the propositions that can have a bearing upon the exercise under consideration.* I believe that a large part of the difficulty that a beginning student has, comes from his not having clearly in mind all these fundamental facts that he needs. For example, if lines are to be proven equal, he must know all the propositions that refer to equal lines, such as congruent triangles, opposite sides of a parallelogram, etc. This in turn necessitates his knowing all the theorems concerning triangles, parallelograms, etc , and proving the triangles congruent will necessitate his proving angles equal, and this likewise requires the theorems concerning equal angles. Now, to get these fundamental facts fixed, I should require the student, at first, to recall with each exercise *all* the prqpositions that might possibly suggest a proof.

He is now ready after following each suggestion to its limit, to select those which it is *possible* to use as well as those which it is *best* to use. When he has done this for some time, until he has "at his tongue's end" all propositions and corollaries that he has proven, he sees in each of the terms involved in a theorem, not only the *one* definition of the term but *many*, and is able to select the particular ones that will lead to a proof. For example, he comes to think of parallel lines not only as those that do not meet but also as those that make with a transversal equal alternate interior angles, equal corresponding angles, or the two interior angles on the same side of the transversal supplementary. He thinks of a parallelogram not only as a quadrilateral whose opposite sides are parallel but also as a quadrilateral whose opposite sides are equal, two of whose sides are equal and parallel, whose diagonals bisect each other, etc. He is now in a fair way not only *to succceea*, but *to enjoy* the subject and get from it very helpful discipline.

4. But there is another very important feature that we have not mentioned, i. e., having recalled all propositions that can possibly relate to the thing to be proven, certain ones may be seen to apply, while again none of these may come directly under the figure as it is given: hence now, and not until now, is the student ready to draw, and draw intelligently, the auxiliary lines needed to make some of these theorems apply.

5. Now supposing that we have discovered theorems that may be made to apply, or by drawing auxiliary lines they may be made to do so; we reverse the steps of the analysis and give the regular synthetic proof.

6. After carefully analyzing the figure as suggested above, if no direct proof can readily be discovered, then *assume the theorem false* and by analysis prove that the assumption leads to an absurdity. This method is called the *indirect method* or *reductio ad absurdum.* As an example: *two*

triangles are congruent when the three sides ot the one are equal respectively to the three sides of the other.

In the other two cases of congruent triangles that the texts generally give before this one is taken up the triangles have angles in each equal, so that when certain sides are made to coincide it is known where the other sides *must* fall. In this case, however, since nothing is known of the angles, we do not know, when two equal sides are made to coincide, where the other sides are going to fall, hence we may assume that they do *not* coincide, but fall as in the figure below, and prove the assumption absurd.

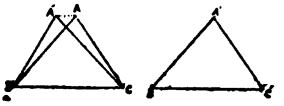


Fig. 1.

Proof.
1. Place △ A'B'C' upon △ ABC so that B'C' will coincide with BC and suppose that A' does not fall upon A.
2. ∵ A'B'=AB and A'C'=AC, ∴ triangles A'BA and A'CA are isosceles.
3. ∴ the perpendicular bisector of A' A will pass through B and C which is absurd.
4. ∴ the assumption that A' does not fall upon A is absurd and the triangles must coincide throughout, and hence are congruent.

To illustrate the steps spoken of above in a single exercise, suppose we have the theorem that, *if the diagonals of a trapezoid are equal the trapezoid is isosceles.*

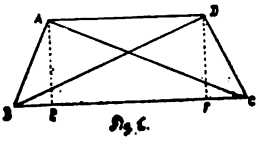


Fig. 2.

1. ∵ the trapezoid is to be proved isosceles it should be drawn so.
2. *Given* the trapezoid ABCD with AC=BD.
3. *To prove* that ABCD is isosceles. Now, use Pascal's advice and "substitute the definition in the place of the name of the thing defined" and say, *to prove* AB=DC.
4. *Analysis.* To prove lines equal requires,
   1. congruent triangles,
   2. parallelograms, etc.

   (a) To prove the triangles congruent requires that we have
      1. The three sides of one equal, respectively, to the three sides of the other,
      2. two angles and a side of one equal, respectively, to two angles and a side of the other, or
      3. an angle and two sides of one equal, respectively, to an angle and two sides of the other, (except in the ambiguous case).

   Again, to prove the angles equal requires,
   1. congruent triangles,
   2. vertical angles,
   3. parallel lines.

   (b) To prove a figure a parallelogram requires
      1. opposite sides parallel,
      2. a pair of opposite sides parallel and equal,
      3. opposite angles equal, etc.

Now, observing our figure, we see that none of these can be proven as the figure stands; we see therefore the need of other lines and seek to draw some line that will give a figure or figures that will enable us to use some

of the theorems recalled. Suppose our proof is to be that of congruent triangles. To get the necessary data in order to prove triangle ABC congruent to triangle BCD we must have in addition to what we already have, angle ACB equal to angle CBD; hence we form congruent triangles involving angles ACB and CBD. To do this we know that two right angles are congruent when the hypotenuse and a leg of one equals the hypotenuse and a leg of the other, and, that parallels intercepted between parallels are equal, and, that perpendiculars to the same line are parallel; hence we drop from A and D perpendiculars to BC and prove triangles AEC and BFD congruent. Now we have angle BCA equal to angle CBD and can prove triangles ABC and BCD congruent and hence the proposition.

Or the analysis might take the following form, called *successive substitution*, as given in *Beman & Smith.*

1. I can prove AB=DC if I can prove triangles BCD and ABC congruent.

2. I can prove these triangles congruent if I can prove angles CBD and ACB equal for BD=AC and BC is common to both.

3. But from the given figure I *can not* prove these angles equal; hence drawing auxiliary lines and proving these angles equal I can reverse the process and give the synthetic proof.

Summarizing the steps taken in dealing with theorems we may say:

1. Assume the theorem true and draw an accurate figure.

2. Get clearly in mind the hypothesis and the conclusion, being sure to understand the full meaning of all terms involved, substituting when necessary "the definition in place of the name of the thing defined."

3. Recall all theorems or definitions that refer to the point to be proven.

4. If none of these seem to apply to the figure as it stands, try to draw auxiliary lines that will involve the thing wanted and that will also give a figure to which some of the known theorems will apply.

5. If successful, then reverse the process and give the regular synthetic proof.

6. But if a *direct proof* is difficult to find, then *assume the theorem false* and show that the assumption leads to an absurdity. It might also be well to call attention to the fact that a *converse* proposition is generally more easily proven by this the *indirect method.*

The solution of a problem is approached in a little different manner from the demonstration of a theorem; and the investigation of problems, together with the discussion of the number of solutions in general, and of the relations existing in the data that give a definite number of solutions, and an indefinite number, and also that make the solution impossible, will supplement the discipline obtained from the demonstrations of theorems and give that desired discipline that will better prepare one to solve the various problems that may arise in other subjects. Edwards in his geometry says: "The manner of approaching the solution of any problem is the same in all subjects, i. e., we are to approach it through analysis."

1. In seeking a key to the solution of a geometric problem, in order to aid the analysis, it is generally best to assume the solution performed and from the elements of the figure, recall some known relations that have already been proven. Having discovered enough of these relations make the construction depend upon them.

2. In beginning the study of these problems already solved in the

texts, the student should be made to know at once that *all* solutions *must* depend upon some known theorem or theorems which should be recalled. I should have the student recall other theorems, if such exist, that might suggest a solution other than the one given in the text. The student must see not only that to solve a problem he must be able to recall some known proposition that makes the construction evident, but he must see also that all problems must be reduced to one or both of the fundamental problems, *to draw a straight line between two points* or to *describe a circle of a given radius about a given point as center*, and also that the required points are found by the intersection of two lines, straight or curved; hence that almost every solution must depend upon *the intersection of certain loci.*

3. The simplest and most common problems that we have in elementary geometry are those in which the analysis leads to the discovery that the points wanted are on certain loci, hence at their intersection. This method is called the *intersection of loci.* As an example, *to describe a circle of given radius to pass through a given point and cut off equal segments from two parallel lines.* Now this depends upon finding the center of the circle. The analysis leads to the discovery that the center of this required circle is the intersection of the locus o points equidistant from two parallel lines, and of the locus of all points equidistant from a given point, which is a straight line and a circumference. Since a straight line will cut a circumference in two points two solutions in general are possible.

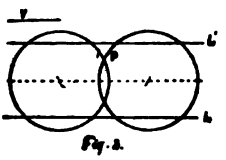


Fig. 2.

The method of *intersection of loci* is used to such an extent in constructive geometry that the student ought to be made familiar with the most common theorems of loci, and have them fresh in mind when taking up this subject.

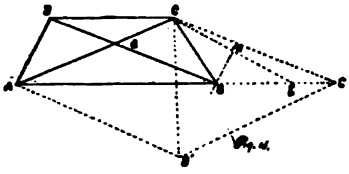
While I am aware that most students go through some sort of analysis without perhaps even being conscious of it, I am sure that the most good will come from the course if the student is made to realize that there is a systematic analysis involved in every discovery of a solution, and if he is required to begin all solutions either written or oral by giving the analysis that led him to see the solution.

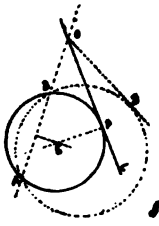
4. It will often occur that the analysis of the figure will not reveal any known relations that will give the means of determining the required points without drawing auxiliary lines that will transform the given figure into a a new one which will involve certain elements of the old, just as was done in the case of theorems. This might be called the *method of transformation.* Just as the most difficult theorems were those that had to be transformed by auxiliary lines, so will this class of problems give the most trouble, and the skill in being able to see the needed auxiliary lines will largely determine a student's success with exercises of this sort.

As an example, suppose we are *to construct a triangle having given two sides and the median to the third.* Now the figure with the median drawn seems to give no way of finding the two remaining vertices when one is fixed but if the median be continued its own length and the extremity joined to the extremities of the base the problem is seen to reduce itself to constructing a triangle when three sides are known.

5. The auxiliary lines needed to transform the figure into a new one, however, are usually drawn parallel to lines in the original figure, i. e., certain lines are considered to be moved parallel to themselves, called

translated, thus giving a new figure which involves elements of the old and which makes the solution evident. Such a method of solution is called the *method of parallel translation*. As an example, *suppose we are to construct a trapezoid having given the diagonals, the angle made by them, and the sum of two adjacent sides*. Assuming the problem solved and the trapezoid to be ABCD, we can get no relations from the figure as it stands to tell us where to intersect the diagonals or where to draw a side if a diagonal is fixed; hence we must transform the figure by auxiliary lines. Drawing through A, AB′ parallel and equal to DB, and through B′, B′C′ parallel and equal to AC, it can be proven that the side AB of the trapezoid coincides with the diagonal of the parallelogram thus formed, and the solution becomes evident.





6. While nearly all problems are finally solved by the first method given, i. e., by the method of *intersection of loci*, still it often occurs that before one finds the required loci a difficult analysis has to be performed and then the method of attack is called simply the *method of analysis*, which in reality is the fundamental method involved in the search for a key to the solution of any problem. The problem *to draw a circle whose circumference shall pass through two given points and also be tangent to a given straight line*, is an example of this kind. Suppose A and B to be the given points and L the given line. Now if A and B be joined and this line extended to meet L in O, it is known that the square of the segment on L from O to the point of tangency of the required circle is equal the product of the segments OA and OB; but it is known that this is also true of the length of the tangent from O to any circle through A and B, hence one has simply to describe any circle through A and B and draw from O a tangent OD to this circle, and then OP on L and equal to OD will give the point of tangency P on the given line and the center of the required circle is easily determined.

Since no two problems are solved alike the power to successfully attack an exercise comes from a great deal of practice, coupled with a close observation of the method by which each exercise was studied, rather than from the study of the few methods given above, but I believe that a student has had his attention called to these general methods he will become much stronger and much more interested in his work and gain to a larger degree the strength to handle the problems of any other department.

Simplicity and Exactness in Geometrical Constructions

EDWARD B. ESCOTT, INSTRUCTOR IN MATHEMATICS, UNIVERSITY OF MICHIGAN

It seems quite remarkable that the systematic study of the questions of simplicity and exactness in problems of geometrical construction has been undertaken only within the last fourteen years. In 1888 M. Emile

Lemoine presented to the meeting of the French Association for the Advancement of Science some general considerations on simplicity in geometrical constructions, and since then he has systematized and completed the theory.

A general exposition of the subject may be found in a book which has just appeared:—

E. LEMOINE. *Geometrographie ou art des Constructions geometriques*, published by C. Naud, Paris.

An article by M. LEMOINE, "*Principles de la Geometrografie ou art des constructions geometriques*, appeared in GRUNERT'S *Archiv der Mathematik und Physik*, in 1901, and a slight sketch of the method in the *Bulletin of the American Mathematical Society*, January, 1902, p. 137. There is a note on the subject in the last edition of *Rouche et de Comberousse's Traite de Geometrie Elementaire.*

By the "geometrographic" construction of a problem, is meant that construction of which the coefficient of simplicity, which will be defined later, is the smallest. It ceases to be geometrographic if a construction is discovered which is still simpler, and this becomes then the geometrographic construction. In order to render the constructions comparable we shall suppose—without particular notice to the contrary—that we may use only a single compass; that there is on the drawing at the beginning only the given magnitudes; that we do not execute on the given magnitudes the definitive drawing unless it is specified by the question:

Geometrography has four aims:

1. It gives for a construction a symbol which is a kind of measure of its simplicity and of its exactness.

2. It leads to processes which enable us to effect, in the simplest manner possible, a construction deduced from a geometric solution.

3. It studies and discusses a construction of which the principle is indicated, to substitute for it in some cases a construction which may differ entirely from the first one.

4. It permits us to compare all the constructions which are known of the same problem and to choose the geometrographic construction.

NOTATION

A (r) or A (MN) denotes a circumference of center A and radius r or MN.

We assume that all lines drawn are indefinite in extent.

To place the edge of the rule on a point is called the operation R_1 or Op. (R_1). Then to place the edge of the rule on two given points is Op. ($2R_1$).

To draw a line along the edge of the rule is Op. (R_2).

To put either point of the compass on a given point is Op. (C_1); then to take between the arms of the compass the distance between two points is Op. ($2C_1$). To put a point of the compass on an undetermined point of a line which is drawn is Op. (C_2).

To draw a circle is Op. (C_3).

Every construction may then be expressed finally by the symbol Op. ($l_1 R_1 + l_2 R_2 + m_1 C_1 + m_2 C_2 + m_3 C_3$), l_1, l_2, m_1, m_2, m_3, being integers. $l_1 + l_2 + m_1 + m_2 + m_3$ will be called the *coefficient of simplicity;* or the *simplicity;* $l_1 + m_1 + m_2$, which corresponds to the operations of preparation, will be called the *coefficient of exactness* or the *exactness;* l_2 and m_3 are

respectively the number of straight lines and the number of circles drawn.

FUNDAMENTAL CONSTRUCTIONS

To draw a line,

1. at will, Op. (R_2).
2. through a given point, Op. (R_1+R_2).
3. through two given points, (Op. ($2R_1+R_2$).

To take a given length in the compass, Op. ($2C_1$).

To draw a circle,

1. at will, Op. (C_2).
2. with an indefinite radius but with a given center, Op. (C_1+C_2),
3. with a given center and which passes through a given point, Op. ($2C_1+C_2$)
4. with an indefinite center but with a given radius, Op. ($2C_1+C_2$).
5. with the radius a given length and the center a fixed point, Op. ($3C_1+C_2$)

To lay off on a line which is drawn a length from an undetermined point of this line, or starting from a point on this line, the length comprised between the arms of the compass. Op. (C_2+C_2), or Op. (C_1+C_2).

ELEMENTARY CLASSICAL PROBLEMS

I. To construct a right angle, or to draw two perpendicular lines.

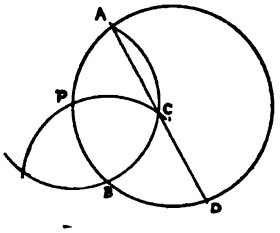
(a) Draw a circle (C_2); a line cutting the circle in A and B (R_2). Connect A and the center O of the circle ($2R_1+R_2$). OA cuts the circle again in C. Draw CB ($2R_1+R_2$); the angle CBA is a right angle. Op. ($4R_1+3R_2+C_2$). Simplicity 8. Exactness 4. 3 lines, 1 circle.

(b) Draw any two circles O(r), O′(r), intersecting in A and B ($2C_2$). Draw AB and OO′ ($4R_1+2R_2$). Op. ($4R_1+2R_2+2C_2$). S. 8; E. 4. 2 lines, 2 circles.

(c) Draw a line (R_2); with any two points of this line as centers draw circles ($2C_2+2C_2$) intersecting in A and B; draw AB ($2R_1+R_2$) Op. ($2R_1+2R_2+2C_2+2C_2$). S. 8; E. 4. 2 lines, 2 circles.

II. To find the length of the radius of a circle of which the center is not given.

P being an arbitrary point on the circle, draw any circle P(r), (C_2+C_2) which cuts the given circle in A and B. Draw B(r) (C_1+C_2) which cuts P(r) in two points. Join either one of them, say C, to A ($2R_1+R_2$) AC cuts the given circle in D. DC is the length of the radius.

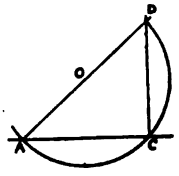


Op. ($2R_1+R_2+C_1+C_2+2C_2$) S. 7; E. 4. 1 line, 2 circles.

III. At a point C on a given line AB, to erect a perpendicular to this line.

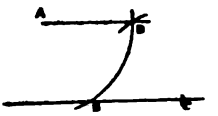
(a) The classical construction has for its symbol Op.($2R_1+R_2+3C_1+3C_2$). S. 9; E. 5. 1 line, 3 circles.

(b) Geometrographic construction. Place one point of the compass in an arbitrary point O, place the other on C (C_1), draw O (OC) (C_2) which cuts CA in A. Draw AO ($2R_1+R_2$) cutting O (OC) in D; draw DC, ($2R_1+R_2$). Op. ($4R_1+2R_2+C_1+C_2$) S. 8; E. 5. 2 lines, 1 circle.



IV. Through a point A to draw a parallel to the line BC. (a) and (b) the two constructions commonly given have the following symbols, Op. $(2R_1+R_2+5C_1+3C_3)$. S. 11; E. 7. 1 line, 3 circles.

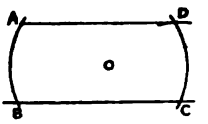
Op. $(3R_1+2R_2+5C_1+3C_3)$. S. 13; E. 8. 2 lines, 3 circles.



(c) Draw A (r) giving B, then B (r) giving C $(2C_1+2C_3)$. Draw C (r) which cuts A (r) in D (C_1+C_3). Draw AD $(2R_1+R_2)$.

Op. $(2R_1+R_2+3C_1+3C_3)$. S. 9: E. 5. 1 line, 3 circles.

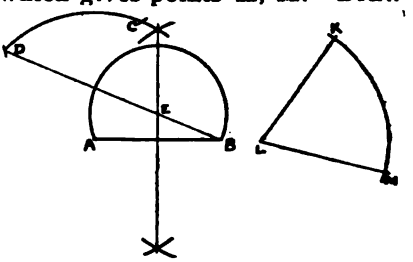
(d) Draw a circle O (OA) (C_1+C_3) which gives B and C. Take AB in the compass $(2C_1)$, draw C (AB) (C_1+C_3) which places D on O (OA) on the same side of BC as A. Draw AD $(2R_1+R_2)$. Op. $(2R_1+R_2+4C_1+2C_3)$. S. 9; E. 6. 1 line, 2 circles.



V. On a given line as chord, to describe a segment of a circle containing a given angle LMN.

(a) Classical construction. Draw BD making with AB an angle equal to LMN; draw the perpendicular bisector of AB and the perpendicular at B to BD, these two perpendiculars intersecting in O; draw O (OA). Op. $(6R_1+3R_2+11C_1+8C_3)$. S. 28; E. 17. 3 lines, 8 circles. In conducting the operations with economy we may reduce the symbol by (C_1+C_3).

(b) Geometrographic construction. Draw the circles A (AB), B (AB) $(3C_1+2C_3)$, then L (AB) (C_1+C_3) which gives points K, M. Draw B (KM) cutting A (AB) in C, and C (KM) cutting same circle in D, $(4C_1+2C_3)$. Draw the perpendicular bisector of AB $(2R_1+R_2)$, and BD $(2R_1+R_2)$ intersecting in E; finally draw E (EA) $(2C_1+C_3)$ which gives the segment required. Op. $(4R_1+2R_2+10C_1+6C_3)$. S. 22. E. 14. 2 lines, 6 circles.

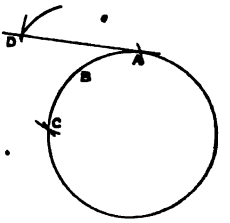


VI. To draw a tangent to a circle of center O, at a point A on the circle.

(a) The common construction is to erect a perpendicular to the radius at its extremity. Op. $(6R_1+3R_2+C_1+C_3)$. S. 11; E. 7. 3 lines, 1 circle.

(b) Geometrographic construction. B being any point of the given circle, draw B(BA) $(2C_1+C_3)$ which cuts it again in C; draw A (AC) $(2C_1+C_3)$ which cuts B (BA) in D. Draw DA the required tangent $(2R_1+R_2)$.

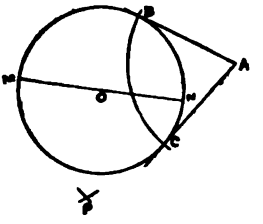
Op. $(2R_1+R_2+4C_1+2C_3)$. S. 9; E. 6. 1 line, 2 circles.



VII. From a point A outside a circle of center O, to draw a tangent to the circle.

(a) Classical construction. Draw OA; describe the circumference which has OA for diameter and cuts the circumference in B and C, the

points of tangency. Draw AB and AC. Op. $(8R_1+4R_2+4C_1+3C_2)$. S. 19; E. 12. 4 lines, 3 circles.



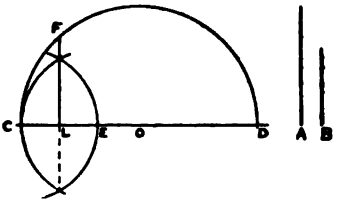
(b) Geometrographic construction. Draw any diameter MN (R_1+R_2); draw M (OA), N(OA) $(4C_1+2C_2)$ intersecting in P. Draw A (OP) $(3C_1+C_2)$ which cuts the given circle in B and C, the points of tangency. Draw the tangents AB and AC. $(4R_1+2R_2)$. Op. $(5R_1+3R_2+7C_1+3C_2)$. S. 18; E. 12. 3 lines, 3 circles.

VIII. To construct the mean proportional X between two given lines A and B. $X^2=A\cdot B$. Let A>B.

(a) (b) and (c) the three constructions commonly given; the first two are based on the properties of the segments of the hypotenuse of a right triangle made by the perpendicular from the vertex of the right angle, and the third is based on the property of the tangent to a circle and the segments of the secant drawn through the same external point as the tangent. They give for simplicity and exactness,—

(a) S. 22; E. 14; (b) S. 28; E. 17; (c) S. 30; E.19.

(d) Geometrographic construction. Draw any line (R_2) and with any point of the line O as center, draw O(A), $(2C_1+C_2+C_3)$ which cuts the line in C and D. Draw C (B) $(3C_1+C_3)$ which places E between C and D; draw E (B), (C_1+C_2) and through the intersections of these two circles draw the perpendicular bisector of CE cutting O (A) in F. CF is the mean proportional. Op. $(2R_1+2R_2+6C_1+C_2+3C_3)$ S. 14; E. 9. 2 lines, 3 circles.



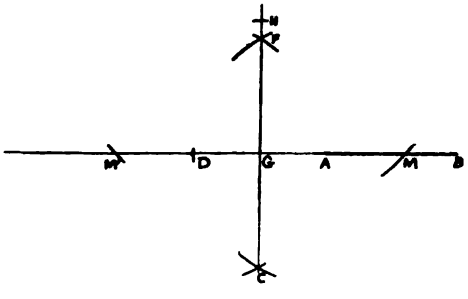
We can prove this by noticing that in the right triangle CFD, $\overline{CF}^2=CL\cdot CD=\frac{B}{2}\cdot 2A=A\,B$.

IX. To divide a line AB in extreme and mean ratio.

(a) Classical construction. In making this construction as it is ordinarily done, we have Op. $(6R_1+3R_2+11C_1+9C_2)$. S. 29; E. 17. 3 lines, 9 circles. By geometrographic principles it may be reduced to Op. $(4R_1+2R_2+10C_1+8C_2)$. S. 24; E. 14. 2 lines, 8 circles.

There are a great number of constructions more simple than the classical construction, among them several geometrographic constructions. The following is one of them.

(b) Geometrographic construction.



Draw A (AB) $(2C_1+C_2)$, which cuts AB in D; draw D (AB) (C_1+C_2) cutting the first circle in F and C. Draw FC cutting AB in G. Draw G (AB) cutting FC in H. While the point of the compass is at G, take the length GB in the compass (C_1), then draw H (GB) (C_1+C_2) cutting AB in M and M'. M is the point of internal division and M' the point of external division. Op. $(2R_1+R_2+$

$6C_1+4C_3$). S. 13; E. 8. 1 line, 4 circles. The simplification in this case is from 29 to 13.

That which precedes is sufficient to show the application of Geometrography. It is remarkable that it has been possible to simplify all the fundamental constructions, sometimes to a very great extent, as in the construction of a mean proportional from 28 to 14, and in the division of a line in extreme and mean ratio from 29 to 13.

The author, M. Lemoine, has applied geometrographic methods to a considerable number of other problems, and has also modified these constructions by allowing other instruments to be used, in particular the square or right triangle used by draughtsmen.

BIOLOGICAL SECTION

Conference of the Biological Section

Two sessions were held, Friday afternoon and Saturday afternoon, March 28 and 29, the latter being a joint session with the Michigan Academy of Science. Both sessions were well attended.

After calling the meeting to order and making announcements, the chairman, Mr. L. Murbach, made some remarks on the proposed amalgamation of the biological section with the Michigan Academy of Science. He said the biological section would better not surrender its identity by fusion with the Michigan Academy of Science, but that the Michigan Academy of Science might form a science-teaching section which the members of the biological section could join, leaving them the opportunity to hold their own conference at any time when the Michigan Academy of Science meets at a different time or place from the Schoolmasters' Club. He pointed out the advantages of the union as, membership in the larger body, opportunity to hear purely scientific papers, and the right to the publications of the proceedings. Pending the action of the Michigan Academy of Science, the Conference proceeded with its program, electing Dr. F. C. Newcombe, chairman, and Miss Genevieve Derby, secretary.

Papers were presented as follows:

THE RELATION OF NATURE STUDY TO HIGH SCHOOL BIOLOGY

RAY A. RANDALL, ASSISTANT PRINCIPAL, GOSHEN (IND.) HIGH SCHOOL

Never before has the subject of science occupied the prominent place in which it stands now. Never has the progress of civilization been so rapid as the last century, during which time science has done so much for the world. Science is the mother of civilization. This advancement was brought about by the mental operations of observation, experiment, classification, deduction, and generalization.

Today all scientific training, all scientific knowledge must come through these primary conceptions and today these primary conceptions

must come through nature's door as in the past. For the child's nature, dependent upon his inherited impulses, necessitates the exercises of his powers through experiences similar to those which took part in the physical and mental development of his ancestors. The lifeless forms of Latin and Greek are no longer in the path of advancement. We now think in our own language, but the present century has yet to blot out the word or the form idea of the old regime. We think the child has the idea when he has only the form in which it is expressed. The present day idea of teaching the child new words by associating the word with the object I believe to be radically wrong in that it makes nature subjective, not objective. The object in the child's hand becomes a part of his experience and that experience expressed will bring the word desired.

Nature study furnishes a basis of reasoning, i. e.: from particular to general, which applied to other studies makes real their notions. It puts the child in the right attitude for work, makes him independent in thought and action, and by its reactive influence moulds the character.

Upon recognizing the aim and importance of nature study in the grades we next turn our attention to the presentation of the subject, to the basis for work and the relation of the work to High School Biology. Many attempts to introduce nature study in the grades have failed, and I dare say it is due to a great extent to the method in vogue of leaving the science work to the grade teacher. To teach nature study in the right way a Col. Parker is needed, a person who can lead others to observe and experiment. Time and a great deal of it is needed. Time to locate the proper field of study, time to take the children to the fields, time to prepare and perform experiments, time to look over note-books with the individual. Systematic work is needed, not a heap of experiment without a definite aim in view. Material both for experiment and observation is need d and should be of the proper kind and plenty of it. In most Graded Schools at the present time nature work is taught by the teachers of the respective grades and in most cases, not knowing the subject they are instructed in the work by the superintendent or science teacher. Due to the nature of the case they cannot fulfill the requirement of a nature study teacher. A specialist born a naturalist would satisfy the condition, and since the importance of a right relation of the child to nature cannot be measured in dollars and cents, an argument against the expense due to the employing a special instructor for the town, has no basis. Again if we recognize nature study as being on a par with reading, language, history, etc., it demands a place in the curriculum and should be presented by a teacher whose acquaintance with the subject is as thorough as with other subjects. One instructor could handle from three to five grades giving six hours a week to a grade by devoting three periods of two hours each to each grade, with satisfaction.

In Biology which furnishes a large share of topics for nature work the natural whole may be the single animal or plant or several living objects taken together to form a society for a definite aim or purpose. Such units or wholes as above mentioned form a natural basis for deductive reasoning, comparisons and generalizations. The course of reasoning should be, in general, first, observation of life in the single thing and repeated recognition of the different fundamental laws: second, application of the laws to unfamiliar objects and life societies.

In the selection of topics strict scientific order should not control.

Factors like material of home environment, seasons of the year, corrrelation with subjects like history, literature, and geography, and ability of the child should figure to a great extent in the sequential arrangement of material. The arrangement of material for study should be such that the pupils in the lower grades could do mainly observational and creative work, gathering data and motives for the generalizing and interpreting which should become more and more prominent and which should gradually increase in difficulty during each successive grade. Repetition should be avoided as much as possible by assigning concrete material for each grade. The provision of material should be such as to insure the largest return to the children. For our work we may rely upon material provided spontaneously by nature or upon the creative effort of the child in planting the seed and caring for the plant or in protecting and caring for animal life. In the case of spontaneous provision, the child under proper direction may bring material to the class-room or he may study the object in its natural habitat.

As a preparation for High School Biology the pupil should have a love for and a sympathy with nature, a desire to investigate and the power to generalize and deduce, correct habits, the where, when, and how of finding material, a scientific spirit, proper nomenclature and facts. Of these the fundamental consideration upon which all the others depend is love of nature which constitutes a means to an end and also an end in itself. Nature study does not aim to make specialists but to educate, to make life happiness in the best sense of the term. Hence the necessity of a sympathetic relation, for to be in touch with nature is to live to enjoy happiness. A desire to investigate would follow in most cases from a sympathetic relation toward nature. The investigation under proper guidance would suggest the fundamental laws already alluded to.

Too much cannot be said as to the formation of habits. By eight or nine the brain reaches the adult size, the fundamental lines are formed and habits contracted become established to show in after years. If habits of indolence, carelessness, disrespect of surroundings have been allowed to develop the reformation in after years will be difficult and perhaps never wholly accomplished. When ready for High School Biology the pupil should be acquainted with nature to the extent that he would know where to get it, and how to handle it after having it in his possession. He should know the parts and their relation in a general way to each other. The inability of pupils to handle material, the timidity in the presence of material is the time wasting element in High School work. Artificial surroundings have made the natural foreign to the senses. The material to appeal to the child must be seen in its natural habitat. The struggle for existence and the protective measures for that struggle appeal to the emotive and intellectual side and stimulate to action.

In treating the subject in a scientific spirit, facts in sufficient number should be in evidence before a conclusion is drawn. Plants and animals should not be presonified or endowed outright with motives.

The use of technical terms has been a subject of much discussion. In most text-books on Biology the technical terms used are thoroughly incorporated in the language of the subject and contain no objectionable terms. Desirable technical terms are acquired when learning the thing to which they belong with as much ease as a foreign language, when a part or organ is discovered a name becomes a necessity and used as a means to communicate and point out to others the name is easily acquired.

But with the many good outlines in the field with a definite understanding as to what should be the preparation for High School Biology we are still confronted with the problem of arrangement of subject matter to bring about the desired relationship between nature study and High School Biology due perhaps to the existing experimental stage of High school Biology and the failure to introduce nature study in the grades. In most cases High School Biology starts with the High School and extends through a period of one semester or two semesters at the most. The pupil appears for the first time in the class-room without any idea of what is expected of him. His habits as to manner of study are fixed to a great degree. He is not in a position to observe and experiment. Ask him a question concerning a certain twig or branch and he will peruse his text for an answer. He will jump at conclusions without reason. There is in the young mind a habit of verbal memorizing, the placing of general notions due to the text-book work. First, then, there must be a reconstruction in the habits of thought which have been successful. At best you have a student beginning nature study. Under such conditions I believe the grade work should be presented in an abbreviated form and if possible bring about a right relationship between the child and nature and place him on a footing for scientific work. What the colleges desire is the student well grounded in fundamental principles rather than one who has a smattering of facts of no real basis for observation and reasoning.

In opening the discussion of the paper, Miss Gertrude Gillmore, of the Washington Normal School, of Detroit, contended that, while especially trained science teachers are necessary to organize and conduct the work, yet, the grade teacher is better fitted to teach the child directly as, she is more familiar with his environment and capability. In answer to the suggestion that the grade teacher is generally ignorant of what to teach and how to teach it, Miss Gillmore responded that she is to take up each subject a month beforehand and do a little at a time under the guidance of the special teacher, until she is prepared. Miss Gillmore then explained her method of conducting such work. Both speakers advocated biological material for nature work rather than minerals or physical phenomena, that are sometimes introduced.

THE RELATION OF LABORATORY, FIELD, AND RECITATION WORK IN BIOLOGY

MISS FRANCES L. STEARNS, ADRIAN, MICH

In Michigan it is no longer necessary to discuss the introduction of the laboratory method in biological sciences. It has proved itself the natural and substantial basis of the high school courses in these subjects and the well-equipped laboratory, if not a part of the school, is recognized as a legitimate demand. We claim for this work that it trains the pupil in habits of observation, accurate recording of observation,—thus developing good mental habits—clear reasoning, and well-balanced judgments. Therefore it better equips him not only to meet and settle problems of science, but to act wisely in the solution of all problems which life brings to him.

It has come to be recognized that the morphological and the physiological work which is possible in the laboratory fails in two directions. First, it fails to give the pupils a first-hand knowledge of plants and animals in their homes, an acquaintance with the life with them in the out-of-doors. A second phase of biological work which cannot be covered in the laboratory is the study of the relationships which exist between living things, their neighbors, and their environment,—the ecological aspect of biology. This department of science is most fascinating for the mature student for it gives him valuable information for the establishment of laws which govern life activities, and to the unscientific, even, the plants and animals become individuals, living individuals with interesting and original ways of doing things.

Field work as a method of instruction for high school pupils is as yet in its experimental stages. Those of us who have been in touch with the spirit of scientific work in this state must teach ecology whether we do so consciously or not for ecology is fundamentally a way of looking at things, the method of approach. It is the question "why" not "what." But the only logical order is *what*, then *why*. Bring these as close together as possible, but we must always precede the explanation,—the theory, by the information, the facts. Give the high school pupil both if you can, but I hold that we should spare no effort to give the boy the first key to the mysteries of life which surrounded him—the what.

There are some of us who still see value in the much ridiculed herbarium and natural-history collection. Field-work is not this but it systematizes and organizes the methods and efforts called out by this kind of work.

It has been said that the kindergarten is the greatest institution ever devised for the education of the parents. I think field work is a close second. The unfamiliarity of methods and facts makes many parents skeptical; they do not see what it is all about. I once heard a man say he was completely demoralized when he went to the woods, and I think he expressed the feeling of not a few pupils. Is not the explanation largely their unfamiliarity with the surroundings? This man's ideals of life—and they were high—had not come to him through the channels of the senses but through written words. I think one remedy for this condition of mind is early work in nature study. When the trees, the flowers, the animals have gained an individuality for themselves, the center of interest will be transferred to them and the child will be left in the proper condition for healthy work,—complete consciousness of self.

The scheme of competitive gardening seems a most sane method of laying foundation-work for science and is certainly meeting with most gratifying results.

The poor grade teacher, ridden to death with fads, will probably groan to see another and will resent the suggestion that the herbarium and natural history collection belongs here. But when the instinct for ownership is strong, the body needing training, and there are endless animal spirits to be worked off, is not this a good time to answer the "What is it?" for natural science?

Until these preparations have been made, what can we do? Familiarize as much as possible by talks preceding the trip, by short excursions near home, by carefully prepared questions distributed beforehand, and ask the question "Why?"

Another word about the recitation. I have left it until the last because it should come last. It should not be the place to give information but one for the pupil to have opportunity of expressing what he has learned, for gathering up facts, and deducing laws, for classifying, and fixing the pupils ideas.

The laboratory, and recitation work, all make legitimate demands on the high school course, but the teacher, the laboratory equipment, the location of the school, arrangement of programme are all factors which must be known before the problem can be solved.

Following this, *Professor Chas. A. Davis, of the University of Michigan*, on the "POSSIBILITIES OF FIELD WORK," emphasized points made in the preceding paper, and contrasted past with present methods. He said all the difficulties of field work are no more fundamental or valid than the objections formerly urged against the laboratory method. The possibilities of field work are great when (1) teachers will prepare for it as they do for other kinds of work, by constant study of the region in which they teach; (2) the size of class sections taken to the field is small, not exceeding twenty; (3) the work is carefully planned and pupils are properly guided and watched; (4) the classes are questioned as to what they see, and are not simply told what the teacher sees; (5) when the special object of the exercise is coördinated with other related topics by questions and suggestions. Possible lines of work in botany, zoölogy, geology, and physiography were then suggested, and teachers who have to do this sort of work with their classes and hope to be successful were urged to take up field work for themselves.

In the discussion following it was evident that the majority of teachers did field work only as a side issue, and that this subject should be further developed; that twenty-five was as large a number as could be profitably taken at one time; that in cities much can be done in the parks; with large numbers it is better to have written directions or questions; that a successful way of doing field work is to take only the most interested students.

Acting on a suggestion previously sent in by Professor S. O. Mast, that it would be desirable to have a set of experiments in Plant Physiology, the chairman appointed a committee to formulate a set of such experiments, with suitable apparatus for a half or a whole year's high school course.

A paper from Miss Grace Ellis, of Grand Rapids, on "PHYSIOLOGY AS A SCIENCE STUDY IN THE HIGH SCHOOLS," made the following points: The optimum and logical preparation for physiology would be that botany, zoölogy, chemistry and physics should precede it. In case it cannot be preceded by these, simple experiments in chemistry and physics must be made in order to make the subjects in physiology comprehensible. Here is the starting point. In the laboratory, guided only by a sheet of directions and tested by questions, the learner finds out something of the composition of his own body. This introductory work may be followed by a set of simple experiments on acids and alkalies, then by tests for respiration, excretion, in order, ending with the study of the nerves and ganglia, especially as seen in the frog. All these are studied experimentally first. Physiology, hygiene, and sanitation should be the interpretation of the simple physiology of our course of study. It is desirable that there be a widespread understanding of the nature of contagious diseases in order that the action of medical boards and boards of health may have a meaning in the minds of

the public at large. The creation of such an understanding seems to me an important duty of the public schools.

Mr. Raymond Pearl, of the University of Michigan, then read a paper on "PRACTICAL PHYSIOLOGY IN THE HIGH SCHOOL." He said in substance: Physiology, as taught in the average high school, is open to criticism from three general standpoints. These are: (1) high school physiology comprises for the most part something other than true physiology; (2) its purpose is too largely one of attempting to impart a concrete knowledge of the human body, without regard to general training; (3) the method of presentation to the student is faulty for two reasons: First, in that the most complex rather than the simple is taken as the starting point; and second, in that the subject is presented dogmatically, i. e., something finally known.

The most important things which will contribute towards the elevation of high-school physiology to the level where it ought to stand are: (1) the use of a rational laboratory method for the purpose of developing the student's general mental powers; (2) the presentation of the subject as a living affair to be investigated, not something dead to be memorized; (3) the substitution of the standpoint of "general physiology" for that of "organ physiology;" (4) the presentation of something of the historical development of the science as a practical means of holding the student's attention.

The program closed with a paper by *Dr. H. S. Jennings, of the University of Michigan*, on "SOME BIOLOGICAL PROBLEMS."*

At the close a resolution was offered that, as physiology in its broader sense is one of the biological studies and may, if properly taught, be made of equal value with any other, it should justly be recognized by university authorities, and that such recognition would promote its better teaching.

Second Conference of the Biological Section

JOINT SESSION WITH THE MICHIGAN ACADEMY OF SCIENCE

In a paper on "ORIGINAL WORK FOR THE HIGH SCHOOL TEACHER," *Mr. E. L. Moseley*, who has done so much for science in the Sandusky High School, gave a most striking illustration, a concrete example, of a piece of original work he had done in locating buried valleys of streams running into Sandusky Bay. His boys accompanied him at one time or another, and one of them helped in the discovery of an old creek bottom that explained one of the problems that was at the time puzzling them. It was shown that such work may furnish a valuable basis for future engineering operations. . . . The conclusion reached was that the valley now filled with mud and covered with water must have existed before the waters of Lake Erie had been raised so far westward, and that if this rise continued, ultimately Sandusky, Toledo, and then Chicago, would be submerged. He then said: "I have been asked to answer certain questions pertaining to original work for the high school teacher. First: how to get a subject? Become a member of the Academy of Science and attend its meetings. You will find out in that way what other investigators are doing and learn of a number of things that need further study. When possible, attend also the meetings of the

* The manuscript for this paper was not obtainable.

American Association for the Advancement of Science. At Pittsburg beginning June 28, will be the last of the summer meetings. After 1902, the annual meetings are to be held convocation week and the first will be in Washington about Jan 1, 1903.

If you can induce scientific men to visit you, you may get valuable hints as to problems for the solution of which your locality affords peculiar advantages. By a few minutes' conversation you may learn things you were anxious to know and could not find out by hours of reading.

A desire to know is the best stimulus to investigation. Oftentimes the result may not be worth publishing, but it is a satisfaction to have learned something about the subject by your own researches. Such knowledge means more to you than what some one else may have found out about the subject, just as the pupil gets benefit from performing experiments for himself instead of merely seeing them performed.

The second question is: how to find time for original work? First, by giving up other things. Miss Cole, who has given us the admirable Flora, of Grand Rapids, Mich., and vicinity, for years devoted to the work her spare time on school days and Saturdays, and the greater part of summer vacations, when she would find board for a week or two at some farm house in a good location and then go to another district until she had made a thorough study of the flora of sixteen townships. The enthusiast in any subject is willing to sacrifice many other things in the pursuit of it.

Many a teacher has the talent to illumine some scientific subject, if it were not overshadowed by the desire to make money. Many whose aptitude for research would lead to valuable discoveries are tempted by the prospect of better pay to seek and ultimately to find a position whose administrative work is too onerous to allow any time for original research. Others devote what spare time can be spared from school work to hearing private pupils, or to some business that can be attended to on Saturdays or after school hours.

Few teachers of science can have any reasonable expectation of getting rich as a result of their discoveries, and if they are not contented to live in a humble way but consider riches essential to their happiness, they are not likely to use any portion ot their slender income for original research or devote to it any time which they might utilize for remunerative work.

The investigator who is devoted to his work may find it necessary frequently to curtail the time he would like to devote to literature and newspapers, to learn ths news of current events mostly from weekly papers or from magazines whose news is more important and reliable than that of the daily papers, and to have some one who has time to read the latter tell him the things in which he is likely to be most interested.

More important than all other means of securing time for original work is the maintenance of health, for its impairment means not only the shortening of life but greatly diminished capacity for labor.

Besides insisting on good ventilation the teacher should be outside at least one hour out of every twenty-four. Living at some distance from the schoolhouse and not using a street car may insure this. The teacher of biology can do much to preserve his health if he goes after school to collect material for his class or to enjoy and study nature in the fields and woods and much for the health and pleasure of his pupils if he takes them along.

Rest after meals and regular and sufficient sleep may prevent one from accomplishing so much in a certain week or term, but will enable him to accomplish more in a lifetime. Likewise mild stimulants, to say nothing of strong ones, diminish in the long run one's capacity for work. Short-sighted is the author of a physiology who commends coffee because it destroys the sense of fatigue. Ambitious persons are prone enough to work on, after brain and nerves and eyes have been taxed until further strain will prevent them fully recovering their original vigor. They need no artificial stimulant to spur these organs to herculean efforts or make them obiivious to the warning of the sense that tells them it is time to rest. With many teachers doubtless the habit of working late at night is contracted while at college. In the literary department working late was formerly not necessary for most students, and it is not now, though many seem to assume that it is. Young ladies who stand high in their classes and yet always retire early, inform me that those who do differently fritter away much of their time during the day, depending on the night time for study.

Frequent moving from place to place may facilitate the study of certain subjects, but for others it must be a serious hindrance. The investigator should have books and notes and specimens classified and arranged so there will be no delay in finding what is wanted. In moving, not only is much time required for packing and unpacking, but much interesting material must be left behind, some things are lost and others broken, the work of rearrangement, which at best will require weeks for a large collection may be interrupted for months or years for the lack of room and suitable cases, and when done, the owner may require a long time to become as familiar with the new arrangement as he was with the old.

After the teacher has been some years in the place and won the respect of many people, they no more think of ousting him because of petty faults than one who was born among them.

In many lines of research acquaintance with the region and with the people such as one cannot get in a single year greatly facilitates one's work. Numerous illustrations of this might be given, did time permit. But the most serious objection to frequent moving is that lines of investigation pertaining to the locality require years in order that the work may be done with such thoroughness as to make it of permanent value.

The teacher of natural science who would imbue his pupils with the spirit of investigation should not be content to invoke their assistance in prosecuting his own researches. He should inspire them with a love of nature. To do this he must take them into the country. Some teachers whose early life was spent in the country or in a village fail to realize when they begin to teach in a city how meagre is their pupil's experience with the subjects they are trying to teach them. Until I take them into the country, some of my pupils have never seen a sheep, a peacock or a snake. Some imagine that strawberries grow on tall bushes. Many of them have scarcely, if ever, in their lives seen a hill or a river, save sometime, perhaps, from a car window. The expressions, "up stream" and "down stream" are meaningless to them. They listen attentively in the classroom to a description of the characteristics of a lake beach, but when shown a mole hill they are not sure that it is not a lake beach. Nor have they more knowledge of a beech tree. Not one in ten ever saw beech trees until taken to them by their teacher. The same is true of the hemlock, the witch hazel and many other interesting plants. Other trees, such as the button-

wood and ash they have seen but never had an opportunity to learn to know them. They do not recognize the note of the meadowlark or the kildeer, or know the difference between a chipping sparrow and a chipmunk.

The burrow of the woodchuck, the chimney of the crayfish, the ants caring for their pupæ and for the plant lice, the protective resemblance to their surroundings of the rabbit, or the grasshopper and whip-poor-will, the protracted flight of the swallow and the quick movements of the kingbird, the singing of the bobolink and brown thrasher;—these things cannot be brought to the school-room. Yet these, and not dried specimens, represent life. To fail to give them any knowledge of these things is to deprive them of a source of enjoyment whose pursuit would do more to enrich their lives than any luxuries that money can buy.

In the discussion following, two of the University men held that it was difficult to find problems on which high school teachers could work, and that they did not usually have the time, though it was held that some sort of original work was almost essential for the best kind of teaching. Yet the principal speaker on this topic, a high school teacher, had done very creditable science work, presenting at the opening of his paper an unfinished piece of work, which was original, to say the least.

Another member, however, presented a more encouraging view of this unpromising situation. He said what holds teachers back from attempting original work is the idea that they must do something great or nothing at all; but little things add to science. There are scientists in the state who wish to enlist teachers in small problems on distribution. Very simple things can be done along this line which in their broader meaning may be very complex. The mere collection of material, when the locality is known, is of importance.

The Description of a New Biological Laboratory

SAMUEL O. MAST, PROFESSOR OF BIOLOGY, HOPE COLLEGE, HOLLAND, MICH.

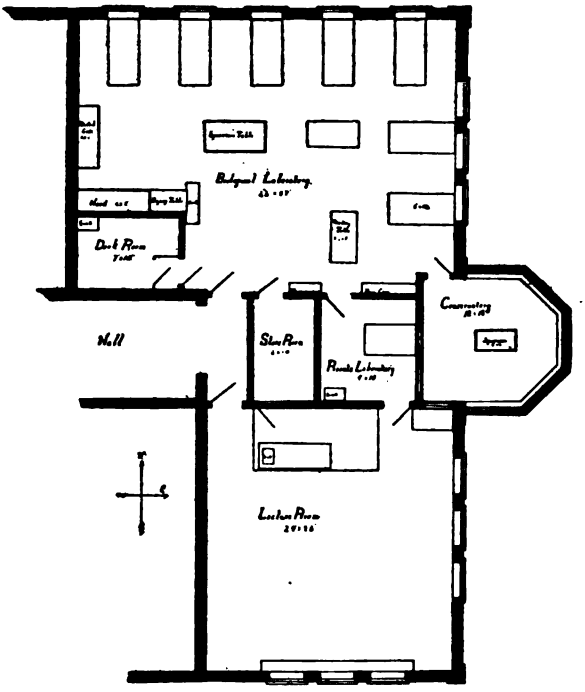
The plans here presented were drafted for a biological laboratory in process of construction at Hope College, Holland, Mich.

The laboratory will occupy the entire east end of the second floor, and in order to avoid direct sunlight as much as possible, will face the north. It is to accommodate 28 students, four at each of the seven working tables. These tables will be supplied with four drawers on either side. The drawers will be arranged one above the other in the middle of the tables. Adjustable swivel chairs with backs will be used at the tables.

There is a conservatory for plants, with glass roof and sides, and a cement floor connected with the sewer system by a drain. The dark room is to be used both for performing physiological experiments in the absence of light and for work in photography. The store room will accommodate not only biological material, but also chemical glassware, stains, etc. A hood which will accommodate three students at one time is supplied with water and gas. The lecture room will seat forty. It is adapted for demonstrations as well as quizzes and lectures, being in close connection with the store room, the private and the general laboratories.

We have planned a private laboratory, 9x12 feet—rather small, but better than none. As it is lighted only through the conservatory, it is

supplied with both gas and electricity. Every instructor should do some special work. This does not necessarily mean that every instructor should be an original investigator; he should be a teacher first of all. The special work he does may be the preparation of material in new ways for student use, or the working over of old experiments. Such a room, where the instructor may work undisturbed by the thoughtlessness of students, will also give them a wholesome notion of the difference between private and public laboratory belongings.



In discussing this paper, *Miss Edith Pettee, of the Eastern High School, Detroit*, gave a description of their NEW BIOLOGICAL LABORATORY, and some of the principal features are here given as it presents the high school side of the same question:

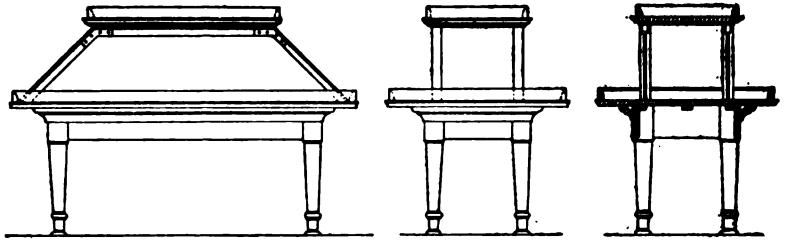
The laboratory faces the north and has three double windows on that side. Before each of these is a large flat iron shaped table, seating eight pupils, with drawer accommodations for four sections. The large table is convenient for beginning classes when materials are used in common while the sloping sides give better light to those away from the window. This light is not as good for compound microscope work as could be gotten at smaller tables before a greater number of windows.

At C is a slate topped table with water and gas and a sink at one end. D is a teacher's table. Both these tables have drawers and cupboards underneath. There are also two cases for apparatus and materials.

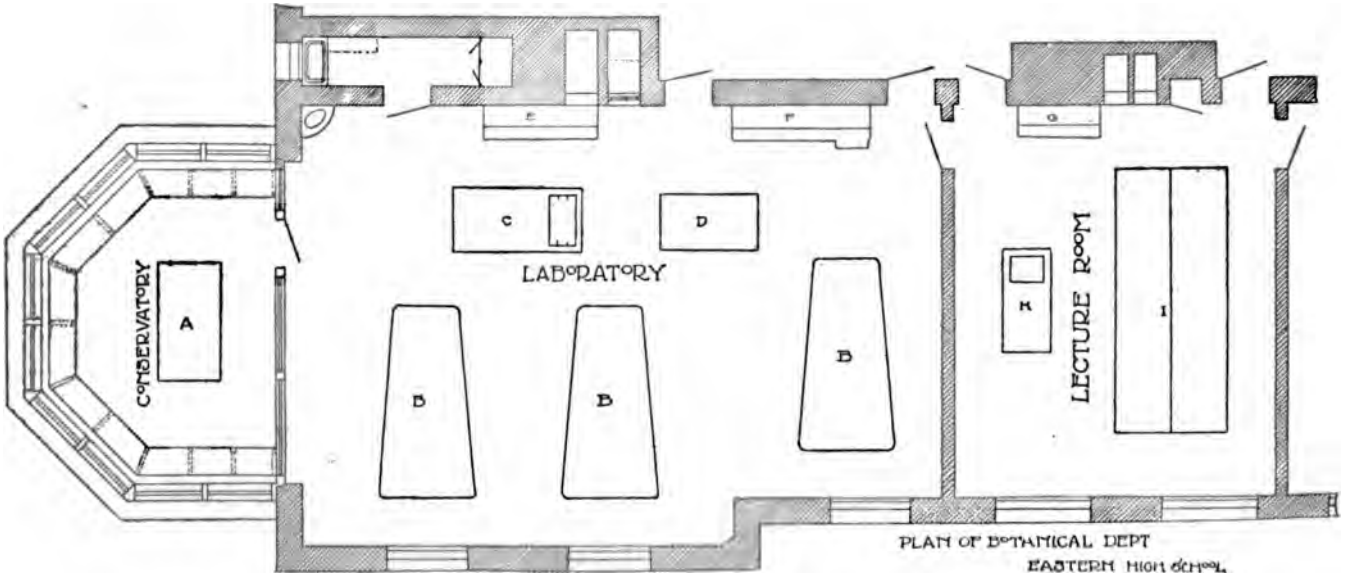
At the side of the laboratory is a small store room which has cupboards, a sink, and a zinc lined wooden box to hold earth. This can be rolled into the conservatory and is a great convenience in potting plants. In this closet is also a gas hot water heater which is connected with all the sinks, a hand basin in the corner of the laboratory, and the conservatory. Turning on the water turns on the lighted gas which heats the water as it runs through the pipes.

A plate glass partition separates the laboratory from the conservatory which has double windows for sides and a double ground glass roof. The cement floor slopes toward a drain pipe in the center.

The metal covered, asbestos lined plant benches are around the sides with steam pipes underneath. It would be better to have the pipes on the



¾" SCALE DETAIL OF TABLE A



These cuts are reduced to one-third size of drawing.

floor as the benches get too hot for the plants. There should be a thermostat connected with the steam pipes. A double-decked aquarium table stands in the center of the conservatory.

The recitation room (lecture room) has a raised platform at I allowing three tiers of seats. There is a long demonstration table, H, which has water and gas and a covered sink at one end. There is a small closet and a case for specimens, G.

In a short talk on "METHODS BY WHICH NEW VARIETIES OF CULTIVATED PLANTS ARE ORIGINATED," *Professor C. F. Wheeler, of the Michigan Agricultural College* gave many ways in which the horticulturist produces such interesting results. Some new products were mentioned,—a daisy, four inches across, will soon be common property. In illustration of the ability of plants to vary with their surroundings it was said that the "dented corn" of the South may be changed to the "flint corn" of the North after three years planting in the latter latitude. In the discussion that followed Professor Davis called attention to the fact that the garden radish, the cabbage, and the cauliflower were the result of selection acting on the plants of the mustard family that had, respectively, somewhat thickened roots, or leaves, or flower-stalks.

Mr. J. W. Matthews, of the Western High School, Detroit, then spoke on "THE KIND OF ZOÖLOGY FOR HIGH SCHOOL WORK," saying in substance: The discussion of the subject of zoölogy in the high school should answer three questions: Why study zoölogy in the high school? When shall it come in the course of study? What shall be the branch of zoölogy presented?

There is no study in the curriculum that can produce better development of the powers of observation, comparison, and classification. No other subject gives such natural material for the development of observation, which is the first step in all study, and comparison, which establishes the facts thus gained, and classification, the logical conclusion. Pupils readily feel at this age the philosophy of the general laws of life, and need the breadth given to thought by considering human life in connection with animal life.

The best time for zoölogy is the second year of the high school course, following a year of botany, which shall have consisted of the study of plants as a whole, their habitats, when they flower, their method of flowering, their uses, etc. In fact much work in "God's laboratory" rather than confinement within the walls of a building with expensive apparatus and a few plants. A high school following such a plan for five years sent out six students who specialized in biology and were chosen assistants in the University of Michigan; four others, who went from college to teach biology in the public schools, or to follow lines of nature work; thus making ten pupils in that period of time inspired to choose life work in biology.

The conference closed with a lecture on "THE GERMICIDAL ACTION OF METALS AND SUNLIGHT," by *Dr. F. G. Novy, of the University of Michigan*. On account of his researches along this line much interest was taken in what was said, an abstract of which is here presented:

The surface or contact action of metals has been studied by chemists for many years. It is well known that certain metals as platinum and especially palladium absorb relatively enormous volumes of hydrogen. The gas is held in combination with the metal and is easily given off in a dissociated or active condition. As a result palladium-hydrogen is capable of exerting

a marked oxidizing action. It may convert, as Hoppe-Seyler pointed out, benzol into phenol, aldehydes into acids, liberate iodine from potassium iodide, etc. Moreover, hydrogen peroxide is formed when it is brought into contact with water.

The contact action of platinum is especially seen in the manufacture of fuming sulphuric acid by the new method. When platinized asbestos at a high temperature is brought into contact with oxygen and sulphur dioxide the metal acts as an oxygen carrier and the result is the formation of sulphur trioxide or sulphuric acid. By this procedure it is possible to prepare pure fuming sulphuric acid and it is more than likely that the "lead chamber" method of manufacture will be entirely done away with.

In 1889 Dr. Miller, the well-known American dentist of Berlin, showed that certain metals such as gold and copper exerted a marked germicidal action when brought into contact with bacteria. He explained this action as probably due to oxygen condensation on the surface of the metal. Behring, the discoverer of diphtheria antitoxine, repeated and confirmed Miller's experiments but the explanation which he offered was very different. He held that the bacteria, by means of their soluble chemical products, dissolved traces of the metals and that thus the germicidal action was brought about. In their studies upon the formation of organic peroxides, Drs. Freer and Novy showed that these substances are readily formed when some metal or even fabric was introduced into the mixture of the ingredients. In other words the surface or contact action of metals was manifested in much the same way as in the manufacture of sulphuric acid by means of contact with platinum. The view was expressed that probably the germicidal action of metals was due, not so much to the solution of the metal employed, as to the formation of peroxides by surface action.

It is well-known that sunlight is destructive to bacteria and the only explanation from a chemical standpoint which has been heretofore brought forward is that hydrogen peroxide is formed under the influence of the sun's rays. There can be very little doubt about the formation of this substance under those conditions, but the amount that is present is hardly sufficient to account for the rapid and intense germicidal action observed. The ultra violet rays are especially active in this regard. The explanation of the action of the sun's rays must be due either to the formation of powerful organic peroxides, such as those described by Drs. Freer and Novy, or to ionization. Investigations along these lines are now being carried on in the Hygienic Laboratory of the University.

PHYSICS SECTION

The Speaking Arc and Wireless Telephony

BY K. E. GUTHE, UNIVERSITY OF MICHIGAN

Ever since the invention of the electromagnetic telephone scientists have tried to reproduce sounds by means of instruments based on an action of the electric current other than magnetic.

Sir W. Preece of England made the first, and, to a certain degree, successful, attempt in this direction by constructing the so-called thermo-

telephone (Proc. Roy. Soc. Apr. 28, 1880). He made use of the alternating heating and cooling of an electrical conductor when a current of varying intensity passes through it. A fine wire subjected to a relatively strong tension is fastened at one end to a membrane. As an electric current is sent through the wire the tension will decrease, while on cooling it returns to its original value. By these variations in the tension the membrane is set into vibration and produces a sound.

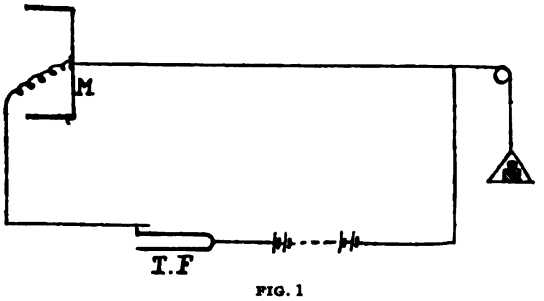


FIG. 1

All depends, then, on the ability of the temperature changes to keep step with the variations of the current, which may be produced in the ordinary way by a microphone. The wire of the thermo-telephone must, of course, be very thin to fulfill the above condition. Preece used a platinum wire 0.0076 centimeter in diameter, and finds that "the articulation, though muffled, was clear, and words could easily be heard." You see a similar instrument here [indicating]. The instrument exhibited is diagrammatically shown in Fig. 1. A phospor-bronze wire 90 centimeters long and 0.02 centimeter in diameter is subjected to a tension of about 200 grams. The membrane (M) is a bladder, which I put freshly on the frame about a week ago. The wire forms part of a circuit leading into one of the further rooms of the laboratory, far enough away to exclude all possibility of our hearing the source of sound directly. In that room a tuning fork is set up, which, as it vibrates, makes and breaks the current. As soon as I turn the switch so as to connect the wire with the circuit, all of you can hear distinctly the sound corresponding to the pitch of the tuning-fork.

Certainly an instrument like this can never vie with an ordinary telephone receiver as far as transmission of speech is concerned, and, indeed, for just about twenty years the electromagnetic telephone reigned supreme and without fear of competition.

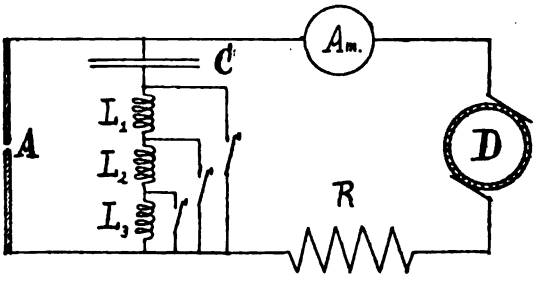


FIG. 2

The conditions have changed somewhat since the "speaking arc" was discovered. Here, as in so many cases, we owe most of our knowledge to the scientific and thorough following up of an accidental observation. In the fall of 1897 Dr. Simon observed while working with an arc light in the physical laboratory of the University of Erlangen, that it produced buzzing sounds similar to those caused by the making and breaking of a primary circuit of an induction coil in an adjoining room. Investigation showed that the two circuits ran parallel to each other for about 15 meters, and that thus currents induced by the working of the induction coil were superposed upon the steady arc-light current. The variations in the current

through the arc gave rise to variations in the density and volume of the incandescent vapor column, and these to sound vibrations in the surrounding air. (Described in Wied. Ann. d. Phys., 64, p. 233, 1898.)

From this observation it was not such a wide step to a reproduction of human speech by the arc light. It was only necessary to superpose the varying currents of a microphone circuit upon the arc-light circuit. The experiments undertaken with this in view have proved, within the last year, remarkably successful.

But, before exhibiting the properties of the speaking arc, or, more strictly, the speech-reproducing arc, let us first consider the arc itself, without any reference to the impressions it gets from the outside. Curiously enough, all these years that scientists were looking for a sound-producing effect of the electric current, the arc has been humming and hissing into their ears without their understanding the meaning of it.

It was Duddell who first found out that the arc was a musical body, and that it was only necessary to give it proper opportunities to have it sing any tune desired. Duddell read in December, 1900, before the English Institution of Electrical Engineers, a very interesting paper on rapid variations in the current through the direct-current arc. That part of his work which is closely connected with our subject deals with the production of clear whistling sounds by the arc itself, when put in parallel with a capacity and an inductive coil whose coefficient of self-inductance may be L. Such a circuit forms an electrical resonator, whose vibration number n is given by the equation

$$n = \frac{1}{2\pi\sqrt{LC}}$$

The resistance, if very small, may be neglected.

All we need, then, is to set this resonator into vibration. It is not necessary to produce in the current variations of the same frequency, but simply to give it many and repeated impulses, just as a tuning-fork is set into vibration by being bowed. These impulses we can easily obtain if we make the arc very short—about one millimeter in length. The burning is then rather irregular, and carbon particles are liable to short-circuit the electrodes frequently, thus continually producing changes in the current. Under such conditions the arc will sing.

The apparatus is shown in Fig. 2. (A) represents the arc, (C) the condenser, (D) the source of current, and (R) the resistance. I have arranged a number of keys in such a way as to cut out different sections of the self-induction, (L_1), (L_2), (L_3),or the whole of it. According to which key I press down, you will hear sounds of a different pitch, all rather high, but distinctly of a musical and not unpleasing nature except when I short-circuit the self-inductance. Then the sound becomes too shrill to be called pleasant; its frequency lies somewhere between 10,000 and 12,000.. If the key connecting the arc with

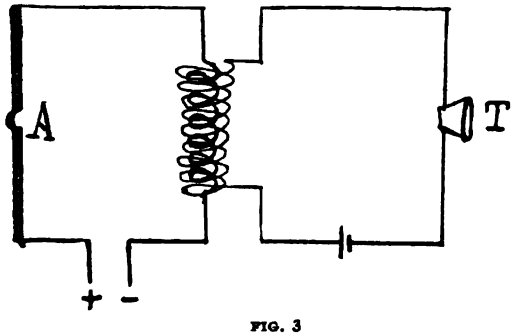


FIG. 3

the resonator circuit is opened the sound stops instantly; on the other hand, notice that no whistling can be produced when the arc is longer and the light steady.

A point of the greatest interest is that we have here the means of producing, by a constant-current dynamo, rapidly alternating currents in the branch containing the condenser and self-inductance, while in the arc we have a pulsating current.

Duddell stated that the hysteresis of an iron core in the inductive coil will instantly stop the tone. I have not found that to be the case. Even with an iron core, the singing can be produced without much trouble, though, I admit, not as easily as without the core. Further, the sound is more liable to vary in pitch, so that for the singing of a regular tune the iron core should be omitted.

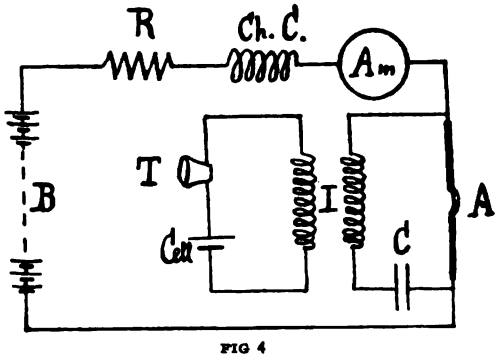


FIG 4

Using a self-inductance with an iron core, made up of a large bundle of thin iron-wire, in series with the capacity, we can make the arc sing. The alternating current produces now a very rapid change in the number of lines of magnetic force. Thus, we can reproduce the famous Elihu Thomson experiments, of which I shall give only two.

If we bring a closed wire near this magnetic field varying at a very rapid rate, currents will be set up in it by electromagnetic induction. On putting such a wire, consisting of several parallel coils and connected to the terminals of an incandescent lamp, on the iron core, the lamp glows. By rapidly slipping this metal ring over the inductance we decrease the self-inductance, and the tone of the arc becomes higher. As soon as the whistling of the arc stops, or as soon as the self-inductance is short-circuited, all these phenomena disappear.

Now let us return to the "speaking arc." The variations in the volume of the incandescent-vapor column are mainly due to the changes in temperature produced by the variations in the current. Suppose that the Joule effect is the same for the arc as for a metallic conductor; then the heat produced in unit time would be given by the formula

$$H = i^2 r,$$

$$\text{and } dH = 2ir\,di.$$

Though this supposition is not exactly correct, experiments carry out the conclusion that the sound effect will be the larger with (1) the larger the variation of the current, and (2) the larger the current through the arc itself.

The number of arrangements proposed by different observers for the best working of the experiment under consideration is quite large. In Simon's original arrangement (Fig. 3) the transmitter (T) was put in series with a cell and one coil of a transformer, while the other coil was in series with the arc. Duddell, (Fig. 4) makes use of a choking coil (Ch.C.), to prevent the variations of the current from passing through the dynamo, and puts the transformer coil (I) and a capacity (C) in parallel with the arc.

I have found, however, that we can produce very satisfactory and strong effects by the simple arrangement shown in Fig. 5.

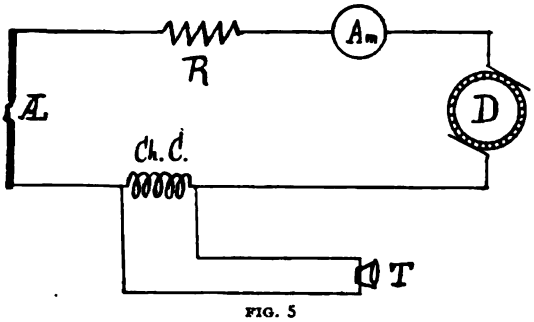


FIG. 5

The arc is produced by a continuous current of 12 amperes between carbons saturated with $NaNO_3$. By doing this we can easily obtain an arc five centimeters long. In series with the arc is a choking coil (Ch. C.), formed by a coil of a large electromagnet ($L=0.007$ h). No capacity is needed in the circuit, and the current is adjusted by ordinary rheostats (R).

The circuit leading to the room where the transmitter (T) is set up is connected to the terminals of the choking coil. The current through the transmitter (Mix and Genest) is about 0.5 ampere. This arrangement is extremely simple, but entirely sufficient to reproduce speech and other sounds with perfect distinctness.

[The experiments consisted in the reproduction of ordinary conversation, various songs, whistling, and violin playing, all being heard distinctly by everyone in the large lecture room, seating one hundred and sixty people.]

Of course, the breaking of the arc stops the sounds, but I observed that for a very short time after the breaking the sound continues, though rapidly decreasing in intensity, showing that the heated gases continue to conduct for a short time. This seems to have escaped other experimenters.

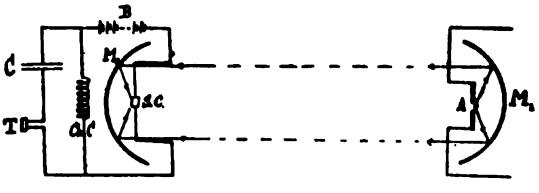


FIG. 6

The arc light then acts as an efficient telephone receiver. Attempts have also been made to use it as a transmitter. Any disturbance of the arc produced by impinging sound waves will change the resistance and consequently the current in the arc-light circuit, which may then be heard in a receiving instrument connected in parallel with the circuit. The results have not been very satisfactory, as the sounds heard are not very loud, and, besides, are mixed up with disturbing sounds, due to the irregularities in the arc light itself.

Since we live now under the sign of wireless telegraphy, it may be of interest that wireless telephony is made possible by the invention of the speech-repeating arc. We may simply make use of Bell's well-known scheme of throwing a beam of light upon a concave spherical surface at whose focus there is a selenium cell. Any change in the intensity of the light will be accompanied by a variation of the resistance of the selenium cell. The whole arrangement is shown in Fig. 6. We have the speaking arc (A) at the focus of one mirror (M_1). The light and heat variations are sent out to the receiving mirror (M_2), with its sensitive cell (SC). This cell is connected in a circuit containing a telephone receiver (T), which responds to any variation of the current due to the change in resistance of

the circuit. The telephone receiver will thus enable us to hear what has been spoken into the transmitter of a distant arc-light circuit.

It is hardly wise to speak of a great commercial value of the speaking arc light or wireless telephony. Nevertheless, we can think of cases where they may be of practical value, but, even without that prospect, the musical and speech-reproducing arcs belong to the most interesting discoveries of the last few years.

NOTE:—A paper, treating a portion of the above subject more in detail, has appeared in the October number of *School Science*, vol. 2, p. 209-215, 1902.

Pupin's Invention

PROFESSOR G. W. PATTERSON, JR., UNIVERSITY OF MICHIGAN

Much interest has been shown by the scientific world in Professor Pupin's invention of the loaded telephone line, an invention which has vastly improved the transmission of speech over long distances. I may, briefly, recall the conditions present in the telephone circuit. The line has, sent into it, a certain periodically varying current, called a complex harmonic current. Very little of this current reaches the receiving apparatus at the distant end, in general less than one per cent. on long lines; the rest is abstracted by the charging of the line and held back by the line's resistance. If this resistance were absent, the charge waves would be transmitted without loss. So the electrostatic capacity of the circuit, in conjunction with the resistance, is an objectionable feature. If it were possible to suppress one or the other, long distance telephony would be possible to any distance. As it appears to be out of the question to suppress either, some counter effect must be sought. Now, it is well known that self-inductance combats capacity, and so increased inductance is the most evident remedy. But how to apply it was the puzzle. It was early suggested by some to put self-inductance in parallel with the capacity, but without good effect; others have tried large inductances in series, which also resulted in failure to produce the desired effect. The theoretical problem was so complex that no one before Pupin had solved it. Consequently, their experiments did not take the proper form. Professor Pupin first settled the theoretical problem, and followed with experiments performed under favorable conditions.

Pupin introduced into the line wire many small equal and equally spaced inductances. The introduction of more self-inductance demands more energy on the line to transmit the same current; but this is no detriment, as the increase of energy hinders the attenuation of the current from wave to wave along the line, Mathematically, a telephone line is like a vibrating cord, and although reasoning by analogy is exceedingly dangerous, yet it may be very helpful when the mathematical parallelism is close, provided it is checked by experiment. Pupin illustrates the telephone problem by means of the vibrating string. Suppose a very long, light, elastic string, which has no stiffness, to vibrate under the influence of simple harmonic impulses communicated to one end. If the string is long, waves will be produced which, because of air and other friction, have smaller and smaller amplitudes as they run along the cord from the source. With short

strings the phenomenon of stationary waves is produced, but in the case considered they are not present to any considerable extent. Had the string more mass in the same cross section, the damping of the waves would be less. Suppose, as a substitute for more uniformly distributed mass, we load the string at frequent intervals by means of many equal and equally spaced masses, we may approximate the uniformly loaded string. If, however, we apply the whole load at one point, or divide it among a few points, we will defeat our object, as the large mass will have a tendency to anchor the string and to reflect the waves and not to transmit them. Thus we may explain the failure of large inductances to improve telephony, when the inductances are located at a few points. Calling a whole wave length 2 Π, if the loads are at intervals A, so small that sin $\frac{A}{2}$ differs little from $\frac{A}{2}$ (say less than 2 per cent.), when the wave is well transmitted.

In the telephone circuit we deal with complex harmonic waves which consist of a combination of simple harmonic waves, each of the form

$$i = I\, e^{-bx} \operatorname{Cos} (pt - Bx)$$

in which i is the current at the distance x from the transmitter at the time t, and I is the maximum current at the origin.

The constants b, p and B have to do with the form and velocity of propagation of the wave; the constant b is the attenuation constant and has for its value

$$b = \sqrt{\frac{pC}{2}\left(\sqrt{p^2L^2 + R^2} + pL\right)},$$

in the case of uniformly distributed resistance (R), capacity (C) and inductance (L). If L is small in comparison with R this reduces to

$$b = \sqrt{\frac{pCR}{2}} \text{ (nearly)};$$

and if L is large in comparison with R

$$b = \frac{R}{2}\sqrt{\frac{C}{L}} \text{ (nearly)}.$$

In the former case higher frequency (larger values of p) causes more attenuation; in the latter case the attenuation is independent of the frequency within the limits of the approximation, and large values of L cause reduced attenuation. Both of these properties are favorably to good telephony; for small attenuation means loudness, and uniform attenuation for all frequencies means faithful reproduction of the quality of the voice.

To illustrate the application of the invention, we may take a line 250 miles long without the loading coils, suppose L = o, R = 9 ohms, C = O. 074 m. f. per mile, b = 0.000004.

This small value of b (0.000004) would make it impossible to hear anything over the line. If to this line we add loading coils having a resistance of 9 ohms extra per mile (in all R = 18 ohms) and an inductance of 0.056 henry per mile, we obtain b = 0.025, in which case speech will be good.

I understand that the Bell Telephone Co. (Am. Tel. & Tel. Co.), to whom Professor Pupin has sold his invention for a princely sum, is now experimenting on a line 6000 miles long, obtained by using in series three New York-Chicago lines, which is equivalent to a metallic circuit between cities 3000 miles apart. The line is said to talk well, and it appears quite

probable that there will be no difficulty in using a line from New York to the Pacific coast. One big advantage from the commercial standpoint is due to the fact that a New York-Chicago line, which now costs $250,000 for copper alone, may be built with loading coils for less than half that amount. If the saving of capital is as great as expected, the price paid Professor Pupin will prove quite moderate.

Carman Opaque Projector

The "Art of Projecting" has a long history, and has developed many forms of apparatus. The "magic lantern" type and its modifications have become so familiar, and is in such common use, however, that it is unnecessary to discuss it. Projection by reflection is far less common; in fact, its possibilities are generally unknown.

Many years ago, attempts at projection by reflection were made in a small way, which resulted in such apparatus as the "Wonder Camera," "Megascope," "Aphengescope," etc. It is probable Chadburn was the first to design an instrument for making projections by reflection, and for a time it was known by his name.

All the earlier forms of instruments, however, attempted only the projection of small pictures of small area on the screen, and with but feeble illumination. Recently a German firm has developed a projector known as the "Epidiascope," a machine weighing many hundreds of pounds and costing many hundreds of dollars. It is highty organized, contains many mirrors, and gives satisfactory results only under the most favorable conditions, and then but for a short period of time. Extensive repairs are frequently necessary.

The Carman Opaque Projector, which is on exhibition before you to-day, is of less weight, is manufactured at a less cost, and is more durable than is any apparatus attempting to do what it actually accomplishes. It is believed to be the only single piece of apparatus that accomplishes the following results, passing from one form to another, without a moment's delay:—

1. The projection of opaque pictures in their true colors.
2. The projection of diagrams from sheets or books.
3. The projection of reading matter or music, from the sheet or printed page.
4. The projection of opaque objects either in a vertical or horizontal position.
5. The projection of all botanical subjects from life, in colors.
6. The projection of apparatus and small machines in operation.
7. The projection of microscopic slides.
8. The projection of micro-photographic slides.
9. The projection of stereopticon slides.
10. The projection of animated life by the use of the moving picture attachment.

The apparatus, as designed, eliminates all mirrors, unless the reversing effect is desired. This effect may be produced either by means of a mirror or a prism.

The features of the Carman Opaque Projector, to which especial attention is called, are· The objective lens, especially designed and built for the

apparatus; the automatic, 90° high candle-power electric lamps used for illumination purposes; the mechanical features making it possible to project stereopticon slides, microscopic slides, and opaque pictures and objects during the same lecture or demonstration.

The Projector which is in operation before you, has been purchased by the University of Michigan for use in the Medical Department, and others are soon to be placed in other universities and colleges.

You are cordially invited to make a close inspection of the apparatus now on exhibition, which inspection will convey to you far more definite ideas than can be given by an oral description.

The Nernst Lamp

SYNOPSIS OF PAPER

The Nernst lamp was originally designed and patented by Dr. Nernst, of the University of Göttengen.

Later the lamp was brought to America by Mr. George Westinghouse, and further developed and patented by his employees, Mr. Wurts, Mr. Potter, Mr. Hanks and others.

The lamp is composed of five principal parts, as follows: The "glower," "ballast," holder, "heater-porcelain" and heater-case.

The glower is the part of the lamp that corresponds most nearly to the filament in the usual form of incandescent lamp. The difference between the filament and the glower is that the glower is made of a mixture of rare earths and a binding material, which are baked together into a slender tube of porcelain. The average tube is about 25 millimetres long and .63 of a millimetre in diameter.

A peculiar feature of the glower is that it is practically a non-conductor when cold, but becomes a conductor of the electric current when sufficiently heated. The glower is not contained in a vacuum bulb, but gives its brilliant white light exposed to the atmosphere. Under these conditions, the life of the glower is, on an average, greater than the life of the highest grade of incandescent lamp fitament.

The ballast is a steadying resistance introduced in series with the glower, for the purpose of regulating the current flow, and in consequence increasing the uniformity of light intensity and increasing the life of the glower. The form of ballast is unique in design, and involves many interesting principles. A full explanation would require more space than is allotted to me.

The heater is composed of platinum wire placed in a small tube of ordinary porcelain, which is placed directly above the glowers, By means of an automatic switch, the current is changed from the heater to the glower as soon as the glower becomes a conductor.

A heater case or glass globe is placed over the glower, in order to raise the temperature of the air in which the glower operates.

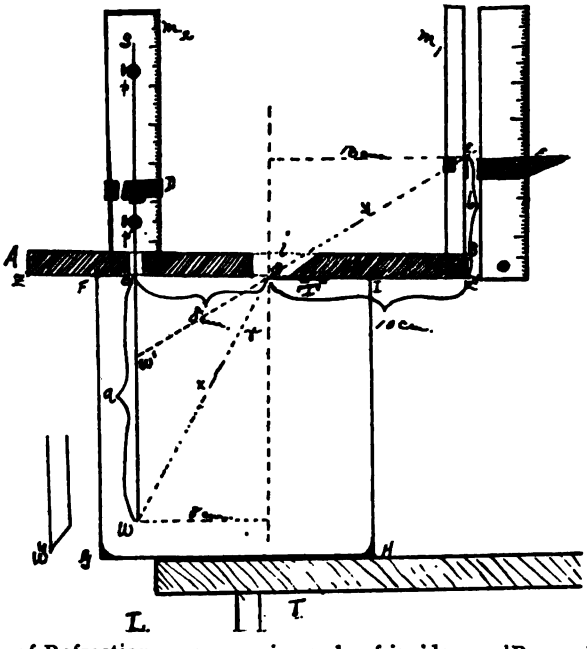
The lamps are made with one, two, three, six and thirty glowers. The efficiency of the six-glower lamp approaches that of the enclosed arc lamp. Tests seem to indicate that the single-glower lamp is at least twenty per cent. more efficient than the best vacuum incandescent lamps.

(ED.—A single glower and six-glower lamp were shown in operation by the speaker.)

The Index of Refraction of Water

CHAS. H. SLATER, PONTIAC, MICH.

The device herewith presented is developed largely from a similar one called an Indexometer, described in *School Science* last May. The method there suggested did not require a dark room nor a bright source of light and so was well adapted to our needs. The per cent of error seems rather large. Our students have used this apparatus in the laboratory with ordinary light and the per cent of error is less than one-half of one per cent.



Index of Refraction = u. i=angle of incidence; ¹R=angle of refraction

$$u = \frac{\text{Sin } i}{\text{Sin } r} \qquad \text{Sin } i = \frac{10}{y};\ \text{sin } r = \frac{8}{x}$$

$$x = \sqrt{a^2 + 8^2} \qquad y = \sqrt{b^2 + 10^2}$$

$$\therefore u = \frac{\text{Sin } i}{\text{Sin } r} = \frac{\frac{10}{y}}{\frac{8}{x}} = \frac{10x}{8y} = \frac{10\sqrt{a^2 + 8^2}}{8\sqrt{f^2 + 10^2}}$$

The construction and method of use is as follows: A rectangular glass jar, F G H I 6.5 cm. by 14 cm. and 18.5 cm. high is filled with the liquid whose index of refraction is desired. Upon the jar, and grooved to closely fit it, is placed a paraffined cover of hardwood, 10 cm. by 20 cm. and 2 cm. thick. This is provided with two openings, and two metric scales, each about 30 cm. long, mortised and glued into the wood at right angles to it as shown in the diagram. A small opening, C, is placed near one end to allow the free movement of the rod S-W (a coarse wire will do) which is fastened to the scale M_2 by means of two binding posts, p and p,[1] so placed

that at all times it will be normal to the under surface of the cover, A B. The scale is provided with a strip of brass, D, bent to clamp the scale and to extend behind and in front of the rod, thereby avoiding parallax. A mark for an index is filed on the rod. The central opening, 2.5 cm. diam., is bevelled back somewhat toward B. On the lower surface of the bevelled edge a piece of thin sheet iron, T, is fasted, so placed that its edge O is normal to the line Z^1O Z and is 10 cm. from Z^1 and 8 cm. from the farther side of the rod S-W. This piece of iron serves as a sight edge at the surface of the liquid. The scale M, is so placed that one edge shall just touch the line Z^1Z which passes through the center of the opening O, and should read from the lower surface of A-B. This scale is also provided with a brass sight edge, E, bent to clamp the scale and yet move easily along it. The rod, S-W is raised so that *W* is at *C*. This is done easily by placing A-B on a glass plate. While W is resting thereon the rod is clamped and a reading is made from the file mark on the rod. It is then lowered to any desired position, placed in position on the jar, and a second reading from the file mark is taken. The difference between these two readings gives the length *A*. If the point, W, be filed very oblique as at W^{11}, it appears much more distinct. In practice it is very important that the sight edge plate T be covered by a thin film of the liquid or the surface will be greatly distorted and consequently a large error introduced. We have found it advisable also to place the jar as indicated on the edge of the table, and to place a common gas jet below or near as at L, to illuminate the point W when adjusting E. A ray of light from W passes the sight edge O, and is bent downward so that W appears to be raised to W^1. The sight edge, E, is then adjusted so that W^1, O, and E seem to be collinear. The reading is then taken, and from this data, the index of refraction computed as shown in the formulæ and table of results. The apparatus is easily made and is inexpensive. The glass jar can be obtained from Eberbach & Son Ann Arbor.

DATA TAKEN FROM STUDENTS' WORK

Reading Z (point of rod, W, on Zero line) = 39.47 cm.

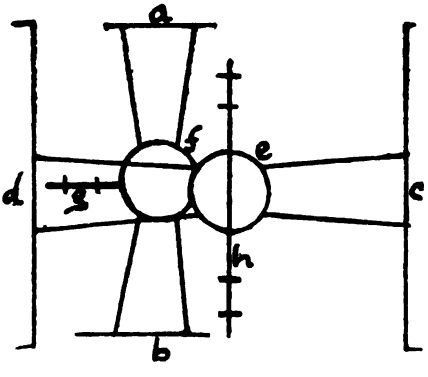
Name	Trial	Reading W, rod down	Z—W=A	B	X	Y	$u = \frac{\text{Sin } i}{\text{Sin } r}$
Mal.	1	24.45	15.02	12.50	17.01	16.00	1.328
G	2	25.44	14.03	11.40	16.14	15.06	1.317
M	3	26.54	12.95	10.35	15.22	14.36	1.324
G	4	28.30	11.17	8.20	13.72	12.93	1.326
M	5	29.00	10.47	7.20	13.17	12.32	1.335
G	6	24.40	15.07	12.60	17.06	16.08	1.327
M	7	25.60	13.87	11.40	16.01	15.16	1.328
G	8	25.00	14.47	11.70	16.53	15.39	1.342
M	9	26.65	12.82	10.10	15.11	14.21	1.329
G	10	27.20	12.27	9.50	14.64	13.79	1.327

Average value for u = 1.328
Correct value = . 1.332
Error = ...004
Per cent = . . . 3-10 %

A Device to Show Composition of Vibrations

H. D. MINCHIN, INSTRUCTOR IN PHYSICS, CENTRAL HIGH SCHOOL, DETROIT, MICH.

The apparatus consists of two small pocket mirrors, *e* and *f*. The mirror *e* is arranged to vibrate vertically by being suspended to two vertical posts, *c* and *d*, by rubber bands.



The mirror *f* is suspended to a vertical post, *a b*, by rubber bands, and vibrates horizontally. The rubber bands may be fastened to the mirrors by wires soldered to the backs.

The two mirrors are so arranged that a beam of light incident upon *e* is reflected to *f* and thence to a screen.

Wires *g* and *h* are fastened to the backs of the mirrors, as per figure. Weights may be placed on these wires, and thus the velocity of vibration may be regulated. The source of light may be a ray of light from a lamp passing through a pin hole in a card, a lantern, or the sun.

By regulating the velocity and a proper adjustment of the tension of the rubber bands, any desired figure may be obtained.

The Joliet Township High School Physical Laboratory

W. J. RISLEY

Referring to the accompanying plan we find that the Department of Physics occupies seven rooms: A recitation room, general laboratory, office and private laboratory, dynamo room, lecture room, dark room and work room. They constitute the entire south and central portions of the fourth floor of the middle section of the building, and contain an aggregate of about three thousand five hundred square feet.

The lecture room, general laboratory and recitation rooms have each telephonic connection through the superintendent's office with the remainder of the building, a dummy electric clock and a thermostat. These rooms have each a large 8′9″ by 3′0″ instructor's table, while the office and work rooms have each a 6′4″ by 3′0″ glass-top work table. Each table has an abundance of drawer space, a stationary pneumatic trough, with waste pipe and connections for hot and cold water, gas, steam, compressed air and electricity.

In the general laboratory are eight stationary students' tables, 6′0″ by 3′6″ and 3′0″ high, at each of which four pupils can work. These are fitted with individual gas cocks, cut-out boxes and cupboards, in which the pupils store their Bunsen burners, gas tubing, ring stand rods, rings and silk-covered cables for electrical connections. For ring stands, brass rods screw into nuts which are fixed in wooden blocks firmly attached to the under side of the table. An office stool, which can be placed under the

table is furnished each pupil, while at the ceiling above each table is a reflector for electric lights. A three-inch stone shelf extends along the entire south wall of the general laboratory and office, and along the east wall of the work room. Gauges for compressed air, gas, steam and water occupy convenient places on the walls, the last being immediately over a stationary marble-top washstand containing four basins. Eight windows, with an aggregate area of nearly two hundred square feet, supply an abundance of good light. These are fitted with ordinary curtains and with dark curtains, by means of which all light may be completely shut off.

The office has desk room for the head of the department and his assistant, a bank of drawers for apparatus, a library closet and a cloak closet.

The 34′0″ by 27′0″ lecture room, with a seating capacity of 100, has a large skylight just above the instructor's table, along the inner edge of which are six incandescent lamps. This skylight and the windows of the room have dark curtains, by means of which all light may be excluded. The seats are arranged in seven consecutive tiers, each 1′0″ higher than the tier in front of it. On an ample platform in the rear of the room is the projection lantern, the 10′0″ by 12′0″ curtain for which is hung above the blackboard just back of the instructor's table.

The dark room will be fitted with the appurtenances which usually accompany such a room, including a complete photographic outfit for taking, developing and printing photographs and slides.

In addition to the above-mentioned laboratory table, the work room will be equipped with a large general work bench, an electrically-propelled lathe for both wood and metal work, and the necessary apparatus for glass-blowing and repairing.

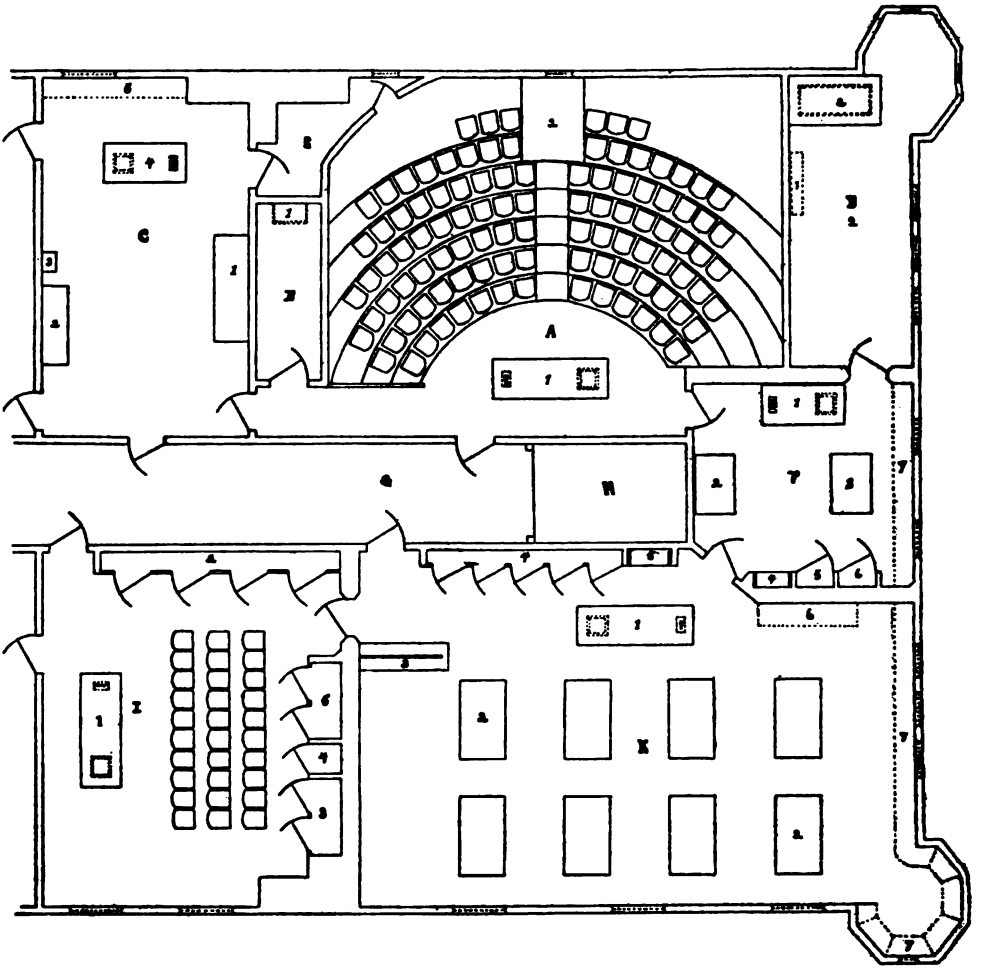
Beneath the raised portion of the lecture room is a large storage space for boxes, battery materials, etc.

Thirteen closets extend from the floor to the 13′0″ ceiling, and having an upper and a lower section, are built in the walls of the general laboratory and recitation room. These closets vary in depth from 1′0″ to 2′6″, and in width from 3′0″ to 4′6″. Their heavy doors close against weather stripping, thus rendering them as nearly dust-proof as practicable. Two banks of thirty-two drawers each are used for smaller pieces of apparatus that have been assembled for the various experiments. Thus it is seen that we have sufficient shelf room for our present and future needs.

In the dynamo room a 3 K. W. motor is operated by power from the city electric light plant. To this motor is directly connected a rotary converter, which can furnish a 3 to 25 volt or a 25 to 125 volt direct current, a single-phase alternating current up to 90 volts, a double-phase or a triple-phase alternating current. The controlling switch board, furnished with stationary ammeters, voltmeters and rheostats, contains also cut-outs for supplying these currents for experiments to be performed in the dynamo room. Concealed cables connect it with the marble distributing switchboard in the general laboratory. This switchboard so stands that it can be studied from either side, and the cables be exposed for testing purposes, etc.

Switches supply the instructor's tables in the botanical and physiographical laboratories and all stndent tables in the physical laboratories with high and low voltage direct, and with city and single phase alternating currents. In addition to these currents all instructor's tables in the physical and chemical laboratories are supplied with two and three-phase alternating currents. With the necessary rheostats for regulating purposes, that

portion of the recitation work requiring electricity is now carried on very satisfactorily with the currents from our own converter. In the not-too-distant future we expect to have our own electrical plant to supply the entire building with light and power.



A. Lecture Room—
1. Instructor's Table.
2. Platform for Projection Lantern.

B. Dynamo Room—
1. Switchboard for Converter.
2. Rotary Converter.

C. Work Shop—
1. Work Bench.
2. Lathe for wood and metal.
3. Motor.
4. Instructor's Table.
5. Stone Shelf.

D. Dark Room—
1. Sink.

E. Toilet Room.

F. Instructor's Private Office.
1. Instructor's Table.
2. 3. Desks.

4. Drawers for Apparatus.
5. Library.
6. Closet.
7. Stone Shelf.

G. Hall to Chemical and Botanical Laboratories

H. Stairway down to third floor.

I. Recitation Room—
1. Instructor's Table.
2. 3. 5. Closets for apparatus.
4. Elevator.

K. Laboratory—
1. Instructor's Table.
2. Students' Tables.
3. Switchboard for Students' Tables.
4. Closet for Apparatus.
5. Drawers for Apparatus.
6. Washstand.
7. Stone shelf.

Discussion of the Physics Note Book Problem

CHAS. H. SLATER, PONTIAC, MICH.

WHAT? When our laboratory work begins, each student is required to provide himself with two note books, a temporary book for taking down the data, etc., while performing the experiments, and a permanent note book in which the data for each exercise is carefully recorded and discussed. The former consists of a small, *bound* book, while the latter is a larger, well bound book of squared paper of medium quality.

WHEN? As the work progresses in the laboratory, the student records all data and observations in the temporary note book. All work is verified by the instructor before another exercise is commenced. The permanent record is then made by the student at home, and is occasionally called in by the instructor for examination and correction. Inasmuch as we usually have but two or three days a week for recitation, the first four or five weeks in the fall are given to text-book work entirely. This, however, lessens the time for laboratory work, hence it seems best here not to require the permanent record to be made in the laboratory, but to devote all the time at our disposal there to the experimental work. Later, at home, the student writes up his permanent record. which is more carefully done and more fully discussed than could have resulted from an endeavor to finish all work in the laboratory.

How? After the first two experiments are completed by all, detailed directions are given the class regarding how to write up and discuss the exercises in making the permanent record. One of the best note books of the previous year is obtained and placed where the students may examine it while writing up their first two exercises. These are to be finished by a certain time and handed in. This work is very carefully examined and marked for correction, and a part of a recitation period is given up to a discussion before the class of the mistakes, corrections, etc., and further suggestions are given for the future work. The books are not called in again until about twelve more experiments are completed. As all results have been previously verified, the discussion of the data, errors, methods, etc., of the experiment receive the most of the attention this time. Each book is then returned with a slip of paper upon which the most important criticisms are noted. Each student is required to see the instructor relative to these corrections. Subsequent examinations of the books are made in a somewhat similar manner, but less time is now required, as the method work by this time is quite well understood and few corrections will now be necessary.

SUPERINTENDENT C. L. BEMIS, IONIA

We have no room devoted solely to laboratory purposes in physics. The apparatus is set up on what might be called a shelf extending the length of the room. Two days each week are given to experiments in physics, and from two to six pupils work at the same time; two only on one set of apparatus.

Each pupil takes notes on what he does in the laboratory, draws pictures of the apparatus, and writes out descriptions of it on loose sheets of paper. These are corrected, after which they are copied into a book so constructed that each leaf may be taken out. After the copying is done, the books are again looked over, and if there are any errors of importance

the leaf is removed and the work copied the second time. Small errors are corrected, but for these the leaf is not taken out. When all is correct, the book is checked and considered passed.

I find that the two most difficult results to secure, so far as the books are concerned, are accurate expression and intelligible drawings. Of the two, the written part seems to be the most difficult, and it is only after repeated re-writing that I secure satisfactory results.

Every student should fill out a laboratory note book.

DE FORREST ROSS, SCIENCE DEPARTMENT, YPSILANTI, MICH.

The laboratory note book is by no means the least of the many perplexing problems that confront the teacher of physics. The average student takes to it as kindly as the boy of old did to the Saturday afternoon "composition." Hence, to make it more attractive and useful to the student is sufficient reason for its place in the questions of a Physics Conference.

That the note book, then, may serve its mission in the highest degree, it would seem to me of first importance that the student be made to see that it has a value to him that he can ill afford to be without. One way to bring this about is to have our colleges and university place a good deal of value on the note book from the high school applicants for admission to these classes, and then for the high school teacher to see that the student understands this attitude of these institutions.

Having established, then, in the student's mind a real value to his note book, he will now take more pride in making it more what it should be—a true record of his efforts, and highly intelligible.

It only remains now to so arrange the order and details of the experiment and observations as to show. in a clear, concise way, that the student has a fairly clear idea of just what he is doing and what he is doing it for. When this is so stated that, without covering a quire or two of note paper, the author will not need to be present to make his work intelligible to one looking over his record, the note book will possess more than a disciplinary value.

H. M. RANDALL, UNIVERSITY OF MICHIGAN

What to require of pupils in the way of writing laboratory notes is a question which does not seem capable of a definite decision, for it depends largely upon the time at the disposal of the teacher. The time for correcting notes, which may be time well spent in larger schools where not so much is demanded of the teachers, is likely to be very poorly spent in smaller schools where teachers are apt to be overworked.

The classroom work, including experimental demonstrations, and the work of keeping the laboratory and its apparatus in order should be well done, as it is by these means that the most physics can be taught, and until the teacher has enough time at his disposal to do this, and some to spare, it is likely to be a poor policy to undertake the correction of rather elaborately written note books.

For several years my pupils were required to write, first in temporary note books and finally in permanent ones, a statement of the problem, the apparatus used, give a complete description of the methods employed, place the results and computations in tabular forms, discuss fully what the results indicated, and make drawings of the apparatus, where such drawings

would simplify the description of apparatus or the method used. The correction and recorrection of such notes required about two hours of my time every evening. and as the forenoons were filled with recitations and the afternoons with laboratory work, there was not left sufficient time to make satisfactory preparation for either. As a remedy, the pupils were expected simply to write the problem, the apparatus used, put results and computations in tabular form, and state very briefly what the results showed. By previously discussing the laboratory problems quite fully in class, and having the laboratory apparatus always in order, it was possible to spend most of the two-hour laboratory period in quizzing pupils about the work they were doing, and to look over the brief notes at the completion of each problem, so that no additional time was required. The time formerly given to correcting notes was largely given to preparation for class work, and, on the whole, the subject was better taught.

W. A. MORSE, WESTERN HIGH SCHOOL, DETROIT, MICH.

In the high school, at least one-third the time given to the subject of physics should be devoted to laboratory work. It is here that the pupil acquires the habit of careful observation and the power to draw his own inferences from the work performed. A carefully kept note book should be the record of the laboratory work. In order that more may be accomplished during the laboratory period, we require the pupils to keep two note books: one (a temporary book) in which all mathematical calculations and manipulations of apparatus are recorded; another in which the working notes are copied, together with a drawing of the apparatus used. This, we believe, gives better opportunity for rapid work in the laboratory, and inspires the pupil to neatness and accuracy in the use of good English in writing out his final notes.

For the permanent notes we use the flexible self-binder, into which the cross-section paper can easily be inserted. All data should be taken at the time of the experiment, and under no circumstances should it be changed until after corrections have been added by the instructor. Both books should be placed in the hands of the teacher for correction, in order that he may see that no after-changes have been made.

The system of correction may be by check marks through the notes or by the use of numbers. We prefer the latter method, as it is less humiliating to the pupil and answers the same purpose.

H. D. MINCHIN, CENTRAL HIGH SCHOOL, DETROIT, MICH.

On the first day of the semester our classes meet for enrollment and assignment of lessons. We then request each pupil to provide himself with the following for laboratory work:

1. A laboratory manual.
2. A temporary note book.
3. A permanent note book.
4. A half dozen sheets cross-section paper.

The temporary note book is to be in size about 6 by 9 inches, containing about 130 pages, and a good quality of paper. The permanent note book is to be about 8 by 10 inches, well bound, good paper, and containing about 100 pages. We choose this size as it affords the required space for tabular forms, for data, without crowding.

On the second day of school the temporary note book and manual are to be brought to class, and we take about two-thirds of the recitation period to give directions for the drawing up of the tabular forms. These are to be drawn up in the temporary note book and handed in for correction. This is done outside of class, and thus the mechanical work is ready when laboratory work begins.

The temporary note book is to be used for all computing, and all observations and notes on the experiment are to be entered therein. This record is to show what the pupil actually observed and what he has to say of his observations.

As data are obtained we give methods of computing results, calling out by discussion what of the data calls for explanation and what results mean. Attention is called to limits of accuracy of data.

At the close of the period all results are checked, and pupils are then expected to replace all apparatus and leave desks in order.

We have tried two methods in discussing data.

1. The class method.
2. The individual method.

The latter is by far the more satisfactory, but requires considerable more of the teacher's time.

In writing up the experiment in the permanent note book, the following order is observed:

1. The first three pages are to be left for index.
2. Begin the writing of all experiments on the left-hand page. On the first line put experiment number and date; then the purpose is to be stated; following this a list of the apparatus with diagrams where necessary; the operations are then given. At the top of the right-hand page the tabular form is to be placed and the discussion follows.

In this discussion is brought out the meaning of the data, the steps in obtaining end sought and conclusion arrived at. The notes made in the temporary note book are used in this discussion.

Each experiment is discussed and written up immediately after it is performed.

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AT THE

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PROCEEDINGS OF THE THIRTY-EIGHTH MEETING, HELD AT ANN ARBOR, MARCH 26, 27, AND 28, 1903

PAPERS

EDITED BY THE CHAIRMEN OF THE VARIOUS SECTIONS

GENERAL MEETING

THE DOCTRINE OF INTEREST AS IT AFFECTS EDUCATION.

PRESIDENT L. H. JONES, MICHIGAN STATE NORMAL COLLEGE.

Interest, as it affects the process of education, is a definite state of mind. It is produced by definite causes, and has definite signification suggestive of appropriate courses of action on the part of teacher and student. The possibility of this condition called interest lies in the self-active nature of the human being. The solicitations made by the external world through the senses arouse this self-active spirit, and suggest and stimulate its reaction upon the objects of the external world, and through these objects a reaction upon its own self, enabling it thus to master its own nature on the one hand, and its environment on the other. This continued mastery of the universe by successive steps, led by interest of one kind or another, is the real process of education. The perfection of education would involve knowing all about the capacities, the possibilities of the human spirit, or the self; of knowing all about all the objects of the universe outside the self; and of seeing and using all the helpful relationships of these objects to the self in the process of life development. Now, the spirit masters an object of study by finding out its attributes, and by viewing these attributes in respect of the self, it finds them gratifying or satisfying a felt need of the soul, the self-active character of the human spirit centers more closely its power of discovery upon the object whose attribute has thus gratified the soul,

through the belief in some form that further investigation will disclose in such object still other attributes which will also give satisfaction to the spirit. It is only under motive of some such kind as this that the self-active spirit ever gives its attention in study. Had it no knowledge of self, and had it never experienced the helpful effect of the attributes of other objects upon itself, no possible interest could be felt. Indeed, the infant has no interest. Its first actions are all instinctive. This interest represents a state of mind produced by the discovery in some object other than itself of an attribute which answers to a felt need of the spirit, together with the expectancy that the same object will, on further study, continue such gratification, or even increase it. Of course the state of interest may become exceedingly complex, as, indeed, it usually does; but gratification and expectancy are two permanent elements of interest. The purpose of this paper is, to some extent, to analyze these two elements and to discover if possible, their sources and the method of their development.

When an attribute of an object has been learned by the spirit in some self-helpful relation, and the expectancy of further gratification has been developed in connection with the same object, we are said to be interested in that object, whatever it may be. The class of objects in which we may thus become interested are as numerous and as diverse as the objects of the physical world outside us, as the mental and moral worlds within us, and as the great institutional worlds which we have created; but the interest itself, the gratification of the nature, and the expectancy, are always internal; that is, interest is a purely subjective, or personal matter. When I say that I am interested in a thing, I mean precisely that my mind is apprehending some one or more attributes of this object, and that this attribute or these attributes, through being thus apprehended, are giving satisfaction to me, or promise to do so through some use which I clearly perceive I may make of it or them in what seems to me to be my life development; and that there is in me an expectancy that this object will through this attribute or attributes, or still other of its attributes, continue to give pleasure.

To illustrate, let a horse-shoe magnet be placed before a child who has hitherto known nothing of its capacity or attributes. The first sight of the object has no special interest to him. Why? Because these attributes of the iron, which become apparent on first notice, are not, by their nature, adapted to gratify or answer in any satisfactory way to any of the child's sensibilities. The color is in no special sense fitted to gratify his aesthetic sense; neither does its size, shape or weight gratify any sense of wonder; nor any pleasurable possibility of the soul. No one of these things makes any appeal to any aspirations of the soul; no one of them appeals to any sense of order in the universe; nor do they arouse any feeling of surprise nor any impression of novelty. So although these commoner attributes of the iron are known to the mind, and this same mind understands the capacities of itself, none of these attributes is for the moment calculated to start up any feeling of satisfaction or gratification. So there is as yet no interest felt in the magnet. But this piece of iron has not yet manifested all of its attributes, because as yet no condition has been fixed which would allow

or cause it to do so. Now place some iron filings on the table and pass the magnet near or over them. The magnetism then manifests itself as a power, drawing these filings to the magnet and causing them to adhere with considerable tenacity. Here is an attribute of the iron, which, by its own character, is fitted to minister to the wonder-loving sense of the child, to his innate love of order, to his fundamental notion of cause and effect, to his own feeling of personal power, and withal to his sense of pleasure in the unexpected, not having expected this power in so unpromising an object. This gratification of the wonder-loving propensity begins and a state of interest is soon developed. The feeling is wholly internal to the child; his self-gratification joined to expectancy, and extended outward and connected to the wonderful power of the magnet as its cause. The gratification of the capacities which are involved in the state of interest are mainly pleasures. Indeed, the pleasurable element is always present with expectancy in the true conditions of interest so far as this state of mind is available in education. It is in this respect to be carefully distinguished from those states of fear and terror which fix the attention and develop states of expectancy, but expectancy of other than pleasurable gratifications. In the true state of interest the continued action of the mind is solicited by the object whose attributes cause the expectation, and thus attention is caused through interest. Interest and attention thus react upon each other, each added degree of attention disclosing new attributes in the object, thus increasing interest, and each added degree of interest soliciting and holding greater attention.

Side by side with this emotional phase of interest, this gratification of the sensibilities, the enjoying of those attributes which give pleasure, there runs another stream of gratifications which is a little difficult to define and separate from the foregoing. This is the pure pleasure which always attends the proper action of normal and healthy faculties, whether physical or mental. This is the law of nature. An organ is a faculty that is made for a certain use: the eye is for seeing; the ear for hearing; the hand for handling; the muscle for contracting; the intellect for reasoning; sensibility for loving and hating; the will for deciding. Each power or faculty, physical or mental, has its appropriate function and is adapted to the doing of some special kind of action. There is an uplift to the spirit whenever it cognizes these powers accomplishing the things for which they are intended. Health, happiness, prosperity, the development and satisfaction of each power all lie in doing naturally, freely and fully that which it is adapted and intended to perform. The real pleasure to which I refer here is not always felt as connected with the organ exercised, but is the gratification of the spirit itself at successful action producing commensurate results.

Thus there are two factors which really make up the pleasurable element in the state of interest:

1. The answering of a felt need of the spirit when it has discovered some attribute of an object which answers directly or indirectly a felt need of the self.

2. The sense of satisfaction which the soul feels on finding powers or capacities normally exercised accomplishing intended results.

These two gratifications, supplemented by the state of expectancy which these develop—that the object under consideration, when further studied through these same capacities of the soul, will yield up other attributes which in their turn will gratify the soul—make up the complete state of interest. A state of enthusiastic interest has all three elements raised to a high degree. The interest of children rests about equally on all these sources. Every faculty of the child, his very muscles, eyes, ears, fingers, toes, intellect, sensibility, will, all are in such harmonious relation to one another and to his environment that each movement answers to an instinctively felt need of action, and every new element of knowledge serves a use in satisfying his capacity for enjoyment. In all competitive games the exercise is usually in itself agreeable because of its proper use of the organs and agencies; but the highest sense of pleasure, and hence the deepest interest, centers around the gratification of the ambition to excel, to conquer, to outdo others, to be first among one's fellows, this possibility being the native endowment of every healthy child, derived, no doubt, from the time when his remote ancestors struggled with the wild animals of the forest, vanquishing them by cunning when brute force was lacking. The boy's interest in the game lasts so long as the exercise in itself continues to give pleasure, or the object of enjoyment, victory—remains to lure him on. Both of these pleasurable elements in interest continue strong through early childhood and youth. They are characteristic of childhood. There is action for the sake of action. Action as pure enjoyment, is characteristic of infancy and childhood. Action for the sake of a purpose is a totally different thing, and is characteristic of later youth and manhood, in fact, the result of education and a mark of culture. It has no place whatever in the form of interest which I am now considering. In infancy action is even almost automatic. In most cases the action is stimulated by external forces. It occurs in response to outside stimulus without even conscious satisfaction. A need of the system is met, but not at first a felt need. The child as yet, therefore, has no interest. Soon, however, he awakes to the pleasure of action of both body and mind, and soon he becomes aware of the fact that action answers to a felt need of himself, is a method of self-expression, hence interesting, because gratifying. Soon this action of body and mind secures for him attributes of these objects,—food, rich colors, beautiful clothes, and the response to a felt need of the soul in these directions renders satisfaction. As this element increases, the interest in things through gratifying response which their attributes make to the soul, the actual enjoyment of mere action, while perhaps not growing less, is certainly becoming relatively less noticeable. At any rate, the enjoyment of the knowledge itself, as it answers to a need of the soul, is capable of so great development that it soon becomes a predominant element. Thus it is that we become interested in things, in the actions of others, and whatever furnishes attributes which serve our uses or give us pleasure. We may now be said to have interests. These things which furnish us satisfaction, with which we like to concern

ourselves, which attract us and solicit and receive our attention—attract us through the gratification which these things produce, and the expectancy of the continued gratification which they promise. In all this development of immediate interest, there is little conscious direction of effort toward an end or ideal, but rather spontaneous action of the whole soul on the inspiration of present satisfaction. There is no lapse of time between the action and the enjoyment of such action. In fact, the enjoyment is in the action itself. In the other case, there is no lapse of time between the appropriation of the attribute of the object, and the pleasure which such appropriation gives to the soul. The whole self is bound up in acts and enjoyments. The person has found himself, has expressed his immediate pleasure in this view of the attributes which have yielded him his natural satisfaction. When the number of things in which one thus feels an interest has enlarged through a more extended knowledge of things, the number of one's interests has correspondingly increased. It is manifest, therefore, that one's range of interests is somewhat definitely related to the scope of his knowledge. Since it is impossible that he should feel an interest in anything upon which he has never employed his powers, and whose attributes have never gratified any power of his mind, it therefore follows, so far as he extends his acquaintance with things, he enlarges the possibility of action, and he also enlarges the probability that he will discover more attributes which will furnish him enjoyment, that will increase the number of his interests, that he will find himself in harmonious touch with more and more elements of his environment, and thereby be enabled to live more richly, and to appropriate to his own gratification a larger share of the things of the universe.

Disciples of Herbart in this country have recently laid great stress upon this process of enlarging the range of interests as a part of education, to the end that the educated person may know life on many sides, thus becoming less dogmatical and more liberal, in fact, that he may be large minded, seeing things through the magnifying glass of a large and rich experience. The Herbartians have persistently advocated the doctrine of many-sided interest and diversity of interests. Through the exclusive devotion to this doctrine some of them have laid themselves liable to be charged with being narrow and dogmatic themselves. This estimate is largely due to the unwise and immature statements made by the Herbartians themselves, but chiefly, perhaps, to the narrow interpretation which they have made of the subject. In many cases the whole range of thought has been expended upon this narrow scope of immediate or native interest. It would seem sometimes, from this state of the case, as if the whole work of education were to be restricted to finding what will please the child at once, and then assisting him to satisfy his present propensities. A moment's reflection will show how utterly unworthy this view of education is. The very possibility of education itself lies in the power to create new ideals and therefore the capacity to develop new powers of enjoyment. With these new capacities come new possibilities of education in the discovery of attributes, which, while they do not at once gratify, most completely develop the powers of mind, or tend to answer the higher needs

of the soul. They are not at first so keenly felt, but are capable of being sensitized by education. Thus comes an opportunity of establishing new and higher objects of interest. It is true that modern civilization is chiefly the power to appreciate and use what is of no interest to the savage. The end of education is not to leave man a gratified savage but to develop him into a noble human being. Therefore, the lines of his interest must be changed, and the range of his interests enlarged. Thus it is not alone the business of the teacher to find what will interest the child, but rather to try to interest him in that which is worthy of his capacities and his destiny. Doubtless the process must begin with present interests, but it must terminate in the development of a line of interests which are human, which are worthy of an exalted being, born in the image of God, and capable of developing into fitness for association with noble presonalities. We must, therefore, look to something more than the gratification of early, or present interests. We must create new ones, must develop new capacities to appreciate, new possibilities of becoming interested in what is worthy in every province of human life and human endeavor. This looks to the development of an interest in a higher grade of attributes, or in the attributes of a higher grade of objects, whose attributes, when mastered, will gratify higher capacities of the soul. In other words, it teaches the child to create for himself ideals of a higher mode of life, and to take an interest in the adaptation of means to the realization of those ideals in a nobler sort of life. Interest in this new mode of life may become as strong and as overpowering as native interest, but its method of development and its law of operation are quite different. The kind of interest which I have thus far been describing is native, immediate, spontaneous. It wells up out of the spirit of the child like the waters of a copious fountain. It comes directly from the gratification which a thing gives to him, and centers itself upon the things whose attributes cause it. If a child should live his childhood and youth under the controlling force of interest of this kind, he would preserve his childlikeness and spontaneity, his happiness and his openness to truth. He would give his whole attention wherever his immediate interest might for the moment lead him. Whatever work he did under such influence would have much the character of play. He might, under its influence, become a great student, and even a great scholar, but hardly a great character. Something more than the influence of present interests is needed to develop strength and stability of character. This native interest is supreme in the childhood of the human being, but it will hardly serve as a proper training for youth and manhood. If one were always to remain a child, there could be nothing further needed than the development for the child intensely this native, immediate interest. Were there never any vicissitudes of life requiring the exercise of a higher virtue and a stronger application of will, there would be little need to develop interest of any higher sort. School education could then consist in making everything as attractive as possible, and all things requiring a real effort in study could be left off. This would, of course, result in no character, only animal life, spontaneous, irrational and unreasoning

life. But manhood and womanhood mean much more than this. They mean the development of character and will, making a thoughtful, manly or womanly person out of every child. For this we must look to a different kind of interest.

As has been stated in an earlier part of this paper, the things in which we may become interested are as numerous and diverse as the objects of the outer world, and of the inner world of mind, and of the institutions which our minds have created. But these classes of things differ widely in one respect, when viewed with reference to the development of interest in them, namely, that some of them interest us immediately because we find in them attributes which cause immediate satisfaction, gratifying powers that are already developed in us, and thus answering to a felt need of our souls. In this case we are interested in these objects as ends of study. Our interest in them is held by the satisfactions which they constantly give us. But there may be other objects that are in no wise interesting to us by reason of any present gratification which their attributes have for us. They do not answer any felt need of the spirit in themselves, but we discover on closer study of their relationships to ourselves that they may be made the means of reaching other things whose attributes do answer our needs, or will answer our needs when we have come into contact with them. Now, it may hardly be said that we at once develop an interest in these objects. It at first seems that we endure them because they are the means by which we reach objects that will interest us. It is the province of education to transform this endurance into a certain sort of interest, which will compel and hold the attention until the mind so masters these objects as to reach through them the objects which will interest the soul through their attributes. This often requires that selected attributes from objects already known to be woven together in memory and thrown upon the canvas of the future in the form of an ideal. The ideal condition, when realized, will furnish attributes which gratify, but the objects which must be used as the means of the realization of this ideal may not gratify the soul which used them. The steps by which one learns to hold his interest in the uninteresting because he has discovered a new relationship of this to the use of his soul is the process of transforming the simple, innocent, irrational, physically active, mentally volatile, child into an intelligent, rational, cultivated person; and between these two extremes lies the large range of our daily teaching, with its necessary deficiencies, its temporary defeats, its final victories; much of it unconscious effort and unconscious tuition, but, as a whole, directed by a more or less well understood philosophy of education.

I know that it is a favorite theory of many that all that is needed is a little time for the child to grow into a cultivated person, that the school should rather be made a place of detention during the growing period. Without ignoring pleasure as a factor, it is sufficient to notice that grown up children are not much superior to young children; but what we need rather is a type of man or woman capable of coping with the growing complexity of modern life. It is true that pleasure is salutatory in its

effect, but its best results accrue only to those who, besides obeying the physical conditions and laws of life, live in the environment of institutions, in exalted companionship with noble human natures, under restrictions which are little appreciated and less liked by the uncultivated man. In other words, the course of education includes the necessary training in the knowledge of communities, in the knowledge of the beneficence of human institutions, the necessity of law and order in the community and self-control in one's self, none of which the savage man in any fair sense appreciates, and many of which are mere means to higher ends. It is thus a large part of education to acquaint the pupil with his spiritual environment, the order of civilization in which he is born, to acquaint him with the immense worth of his spiritual influence, and thus to build up within him a standard of life in harmony with his nature and destiny.

To live up to the high standard of life here outlined, in the midst of a civilization still holding many of the crudities and evils of savage life requires that each of us shall daily do many things which in themselves are not only not pleasurable but which are positively distasteful. In and of itself much of our work is pure drudgery, while much of it requires us to bear large responsibilities, to endure petty annoyances, and to do disagreeable things. It is impossible that we should feel real interest in these things by reason of any gratification of any power of ours by any original attribute of theirs. There is therefore no motive to do these things unless one can be found elsewhere but so related to these acts as to constitute for the time being a valid vicarious interest. The end sought must not only justify but also glorify the means. The contemplation of the ideal end must give a pleasure akin to that felt in its realization, in order that this pleasure shall accompany the doing of the drudgery, gliding at last into the glorious realization of the end achieved by the dull drudgery, till the mind scarcely any longer distinguishes the limits of each and the whole is fused into one glorious sense of achievement. This transformation is complete when this attribute—the relation of means has been clearly seen and the means has accomplished the longed-for end; then the means itself—though it be drudgery—is now loved for one of its own attributes—this very capacity to achieve desired ends—then is *immediate* interest in the means itself developed in place of vicarious or mediate interest.

Happy is he in life who can so live that the effulgent glory of his ideal life is thrown backward till it lights up all the pathway of his actual life. His ideal is the magnet pole of his life. He will drudge for ten hours per day if need be in order that he may found his ideal family life and keep it sweet and pure under the shadow of his own vine and fig tree. He will march with steady step to the cannon's mouth, at the call of his patriotic ideal, counting life and limb as mere incidents in the series of movements by which civil and religious liberty are established. He will council together with his neighbors, foregoing his personal preference to the end that the social order may be unbroken. His interests are so set in the best things that he cannot stoop to the mean or low; and the fine sense of gratification coming from the realization within himself of a high

grade of manhood compensates for laborious efforts and frequent disappointments in external purposes. The perfection of culture is to think clearly, to aspire nobly, to drudge cheerfully, to sympathize broadly, to decide righteously and to perform ably. The undeveloped child can do none of these things. The undeveloped germ of the possibility to do these things is his by native endowment. The province of eduation lies between these two extremes. To understand the philosophy of education we must study the child as he is, to get our point of starting. But we must study the possibilities of man, as he has expressed himself in history, literature, art and achievement, to get the other point which sets our trend and gives direction to our educational effort.

FRENCH SECTION

TO WHAT ACCOMPLISHMENT SHOULD THE TWO YEARS' COURSE IN HIGH SCHOOL BE DIRECTED?

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In arranging a plan for French work in high schools two groups of pupils must be considered. First: those fitting themselves for entrance to a university, and second: pupils whose systematic training will end with their high school course. The former must be well provided for, or a school can claim no place on the "diploma list," while the best interests of the latter, constituting the majority in each class, should be equally our care. This diversity of purpose on the part of students, however, presents to my mind no added difficulty. For I would instruct both classes of pupils in exactly the same way. Not that the same method could be advantageously employed in the lower grades, or outside of schools in many instances. Immaturity of mind in the one case, and a lack of adequate technical preparation in English in the other would render the adoption of such a course unwise. But to those who have entered the high school after thorough work in the lower grades grammatical terms should be perfectly familiar, logical presentation of grammatical principles intelligible, and, in general, the grammatical path to the fair land of France in speech and literature the most direct one. But I would make this path a broad and beautiful avenue, well provided with all that can render the journey pleasant, relieve fatigue, and prevent monotony, while not detaining the traveller too long nor deflecting his steps.

My conviction that even those high school pupils not contemplating a university course should be trained on strictly scientific lines, is based

upon personal observation and experience. I have seen the efficacy of various methods practically tested on French soil. For greater clearness, I will separate into four classes those American students of French whom I have observd abroad.

I. Those with *no* previous knowledge of French.

II. Victims of the exclusively "conversational" method.

III. Students who had pursued the laborious course formerly traversed in studying ancient languages.

IV. Those who, with careful study of grammatical principles, had acquired an ability to apply such principles through systematic drill in conversation, dictation, composition, etc.

I have noted that beginners soon overtake those instructed in America by the conversational method exclusively, and that students possessing only theoretic knowledge find themselves utterly helpless regarding the spoken language. On the other hand, the results of a course of study furnishing a thorough elementary knowledge of grammar strengthened by constant practical application are in the highest degree satisfactory. A few weeks' stay in Paris then suffices to equip the student with a supply of words and phrases adequate for all needs, whether his aim be science, art, or general culture. Each acquisition finds its allotted place, all resting on a firm and broad foundation.

It is true that only a small proportion of our students will test their knowledge of French in Paris. But it will be conceded that what best prepares one for further study or social intercourse in France constitutes likewise the best preparation for any later use of the language.

Since the claims of grammar for an important place in our course have been now presented, it remains to be considered what should be the scope of work in this line. In my opinion, we must limit ourselves to the essential, the eminently practical, while taking care that our foundation be fitted for permanency. Historical grammar, and syntactic intricacies should be reserved for later study, even in longer courses. In the two years' course, lack of time would prevent their introduction; but aside from this, inaccuracy and timidity of memory often result from too early invasion of these grammatical provinces. This reflection would not preclude, however, the occasional explanation of a derivation (especially useful to Latin pupils as an aid to correct orthographic accent) or the notice of English-French cognates. Such observations tend to increase interest, and prove to pupils the correlation of their studies—an important point.

The choice of a text-book in grammar is a serious thing, even though it be used simply as a manual. With eagerness I examine each new aspirant for honors in this field that reaches me, only to lay it down with that feeling at my heart occasioned by "hope deferred." With due appreciation of admirable points in many new grammars, I have not yet seen what seems to me the ideal book for English speaking pupils. A thought expressed in a recent article on modern architecture might find an application here, in many cases:—"Architects now originate simply for the sake of novelty, not in order to produce something better, but merely something unfamiliar."

My objection to most of the new grammars is that their plan is not sufficiently scientific. They do not furnish the foundation required by all varieties of students. Other text-books with excellent plan omit any presentation of French equivalents for grammatical terms, thus necessitating the consumption of much extra time in case French is to be largely the language of the class-room.

Of the grammars with which I am acquainted, I prefer Whitney's as a text-book for beginners, owing to its logical presentation of most of the essential principles, and its systematic arrangement. Retaining its frame work, the material parts may be adapted and elaborated to suit one's own ideas. In my opinion, an equivalent to Part I. of this grammar furnishes sufficient knowledge of principles for our course. The eight long years spent on French grammar in the schools of Germany do not produce the practical results that would satisfy me as a teacher, and such drudgery may engender great distaste for the subject. Who knows but that in the irksomeness of this eight years bondage to "dem Kleinen und dem grossen Ploetz" may lie the hidden cause of many a modern German's lack of love for his French brother? But a genuine "Prussian drill" in grammatical forms and fundamental rules cannot be dispensed with in any thorough course.

All knowledge of rules or of word-forms, however, avails little without a reliable vocabulary. The most skillful cook cannot make bread without flour. Therefore, an absolute *possession* of the most commonly used words should be one of our requirements. To stimulate endeavor, and accomplish accuracy in this regard may be recommended an occasional "vocabulary down," conducted on a plan similar to that of the old fashioned "spell-down." In my experience, this exercise rather saves than consumes extra time in the end, and "idiom-downs" form another profitable pastime for pupils somewhat advanced.

The entrance requirements of our state university most wisely emphasize a practical knowledge of French rather than the reading of a long list of texts. I speak feelingly on the subject of text-lists, for the diversity of those required for entrance into various colleges has repeatedly caused me great perplexity. In gathering data for a paper presented by me at a conference held at Chicago University a few years ago, I ascertained that if, in a class of four, each member were preparing for one of four certain colleges respectively, the class would be obliged to read twenty-seven different texts, to say nothing of other class work. A special list of texts for the two years' course seems to me inexpedient, although the reading should be confined to modern authors, and might well include a comedy. Quality and not quantity of work in reading is our most important consideration. Translating into English, moreover, is a matter that almost takes care of itself. It has a place in every good course, and its usefulness is apparent. But, with many instructors, far too much time is devoted to it. Only on rare occasions is it necessary to require the translation, in class, of a review lesson. Its substance may be narated by pupils consecutively in well-rounded French sentences, or may be reproduced in answer to questions from the

instructor, or from pupils in turn. Conversation among students in class by way of query and answer may well begin as soon as one tense of the first verb has been learned, in addition to a few nouns. Pupils are delighted at the achievement of these first tottering steps, and as surprised as was Molière's M. Jourdain when he discovered that he could talk prose. These slight successes also bring confidence, a most important aid in acquiring a foreign tongue, particularly in the case of boys and girls of high school age—that period of blushing and stammering self-consciousness. This same self-consciousness is the most formidable hindrance to correct pronunciation. There are individuals in every class who must be drilled by themselves. They are never willing to risk possible ridicule by attempting to roll an "r" or to produce one of the nasal sounds in the presence of classmates untill such feats have become quite safe and easy. In these private rehearsals I have more than once discovered a "star-pupil," thus reaping a speedy reward for my extra labor. Each correct enunciation of a French sound, each correct utterance of a French expression, is a firm step in advance, for our vocal organs, no less than our brains, are wondrously influenced by habit. The difficulty in securing sufficient practice of this kind in large classes may be met by concerted repetition, sometimes with closed books, and even with closed eyes, in order to insure complete attention to sound.

Thus, step by step, our student acquires the ability to pronounce correctly and fluently even in sight-reading, as well as to recognize readily French words and expressions when spoken. Dictation exercises become a pleasure, and confidence in himself brings increased zest for further study.

In composition work, which should be one of the prominent features of our plan, modern methods have produced a most valuable change, and what was often drudgery in former years has become an agreeable task. No longer does the student dread composition days. In fact, repeatedly individual pupils have requested me to oversee extra work in this line, asserting that "it is so much fun to write the exercises." If, immediately upon the acquisition of barely sufficient material, the student is required to write original sentences during the recitation period—a little privilege that I often attach to the speedy completion of assigned work—or to prepare illustrative expressions as part of his work in learning idioms, a beginning of composition work is made, and the transition to connected sentences follows naturally. In my monthly tests, after the first few weeks, all questions are expressed in French, and not one English word appears in the answers to these questions, or, in fact, on any examination paper from the beginning of work. I require no translation from French into English in any examination.

To one who regrets the present rareness among students of an old-fashioned memory, it is gratifying to note the growing encouragement given to memorizing choice bits of French verse. The importance of this exercise should exact a definite place for it in our plan of work. It has long been my custom to have second year pupils memorize with distributed parts whole acts from some modern comedy read by them. This never fails to interest a class, and the results are always more than satisfactory.

What may we then secure by the two years' course? I answer: A correct and fluent pronunciation, together with a readiness in recognizing French spoken words; a good working vocabulary and acquaintance with common idioms; the ability to translate, into or from French, language of ordinary difficulty, and to write easy French off-hand; and a practical knowledge of grammatical principles. To these items should be added a cursory acquaintance with France, her life and literature.

Moreover, without losing sight of our aim, we must not fail to awaken and maintain on the part of students a keen interest in their work. When interest flags, progress is slow and awkward. To popularize the study of French, to increase the number of pupils pursuing it is by no means the least important part of our task. Fortunately for us, language work may be presented in endless variety if we choose to avail ourselves of its possibilities.

MATHEMATICAL SECTION

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON THE TEACHING OF ELEMENTARY MATHEMATICS.

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The report of the British Association Committee on the Teaching of Mathematics, as presented by its Chairman at the Belfast meeting in 1902, is as follows:

In submitting their present report, the committee desire to point out that this is not the first occasion on which the British Association has attempted to deal with the teaching of elementary mathematics. About thirty years ago, a similar body was appointed to consider a part of the subject, viz., "the possibility of improving the methods of instruction in elementary geometry," and two reports were presented, one at the Bradford meeting in 1873 (see the Report volume for that year, p. 459), the other at the Glasgow meeting in 1876 (see the Report volume for that year, p. 8).

The two reports advert to some of the difficulties that obstruct improvements in the teaching of geometry. One of these is alleged to be "the necessity of one fixed and definite standard for examination purposes"; apparently, it was assumed that this fixed and definite standard should not merely be required from all candidates in any one examination, but also be applied to all examinations throughout the country. In order to secure the uniformity thus postulated, the committee thinking that no text-book had been produced fit to succeed Euclid in the position of authority, and deeming it improbable that such a book could be produced by the joint action of

selected individuals, suggested the publication of an authorized syllabus. In their second report they discussed the merits of a particular syllabus—that of the Association for the Improvement of Geometrical Teaching; but, in spite of such commendation as was then expressed, the syllabus has not been generally adopted.

It is still true that (in the words of the former Committee) "in this country at present teaching is guided largely by the requirements of examinations." For some time to come, the practice of the country is not unlikely to allow examinations to retain at least a partial domination over teaching in schools. Accordingly, it seems to be a preliminary requisite that examinations should be modified; and, where it is possible, these modifications in the examinations should leave greater freedom to the teacher, and give him more assistance than at present.

On the other hand, there is a tendency in this country whereby, in such matters as teaching and examination, the changes are only gradually effected, and progress comes only by slow degrees. Accordingly, the general recommendations submitted in this report are such that they can be introduced easily and without any great alteration of the best present practice. It is the hope of the Committee that the recommendations, if adopted, will constitute merely the first stage in a gradual improvement both of teaching and of examinations. For the most part only broad lines of change are suggested; this has been done in order to leave as much freedom as possible to teachers for the development of their methods in the light of their experience.

IS UNIFORMITY IMPERATIVE?

The Committee do not consider that a single method of teaching mathematics should be imposed uniformly upon all classes of students, for the only variations then possible would be limited by the individuality of the teacher. In their opinion, different methods may be adopted for various classes of students, according to the needs of the students, and corresponding types of examinations should be used.

It is generally, if not universally, conceded that a proper training in mathematics is an important part of a liberal education. The value of the training depends upon the comprehension of the aims of the mathematical subjects chosen, upon the grasp of the fundamental notions involved, and upon the attention paid to the logical sequence of the arguments. On the other hand, it is freely claimed that, in the training of students for technical aims such as the profession of engineering, a knowledge of results and a facility in using them are more important than familiarity with the mathematical processes by which the results are established with rigid precision. This divergence of needs belongs, however, to a later stage in the training of students. In the earliest stages, when the elements of mathematics are being acquired, the processes can be substantially the same for all students; and many of the following recommendations are directed towards the improvement of those processes.

TEACHING OF PRACTICAL GEOMETRY.

The former Committee recommended (and the present Committee desire to emphasize the recommendation) that the teaching of demonstrative geometry should be preceded by the teaching of practical and experimental geometry, together with a considerable amount of accurate drawing and measurement. This practice should be adopted, whether Euclid be retained, or be replaced by some authorized text-book or syllabus, or if no authority for demonstrative geometry be retained.

Simple instruments and experimental methods should be employed exclusively in the earliest stages, until the learner has become familiarized with some of the notions of geometry and some of the properties of geometrical figures, plane and solid. Easy deductive reasoning should be introduced as soon as possible; and thereafter the two processes should be employed side by side, because practical geometry can be made an illuminating and interesting supplement to the reasoned results obtained in demonstrative geometry. It is desirable that the range of the practical course and the experimental methods adopted should be left in large measure to the judgment of the teacher; and two schedules of suggestions, intended for different classes of students, have been submitted to the Committee by Mr. Eggar and Professor Perry respectively, and are added as an Appendix to this Report.

SHOULD THERE BE A SINGLE AUTHORITY IN GEOMETRY?

In the opinion of the Committee, it is not necessary that one (and only one) text-book should be placed in the position of authority in demonstrative geometry, nor is it necessary that there should be only a single syllabus in control of all examinations. Each large examining body might propound its own syllabus, in the construction of which regard would be paid to the average requirements of the examinees.

Thus an examining body might retain Euclid, to the extent of requiring his logical order. But when the retention of that order is enforced, it is undesirable that Euclid's method of treatment should always be adopted; thus the use of hypothetical constructions should be permitted. It is equally undesirable to insist upon Euclid's order in the subject-matter; thus a large part of the contents of Books III. and IV. could be studied before the student comes to the consideration of the greater part of Book II.

In every case, the details of any syllabus should not be made too precise. It is preferable to leave as much freedom as possible, consistently with the range to be covered, for in that way the individuality of the teacher can have its most useful scope. It is the competent teacher, not the examining body, who best can find out what sequence is most suited educationally to the particular class that has to be taught.

A suggestion has been made that some Central Board might be instituted to exercise control over the modifications made from time to time

in every syllabus issued by an examining body. It is not inconceivable that such a Board might prove useful in helping to avoid the logical chaos occasionally characteristic of the subject known as Geometrical Conics. But there is reason to doubt whether the authority of any such Central Board would be generally recognized.

Opinions differ as to whether arithmetical notions should be introduced into demonstrative geometry, and whether algebraic methods should be used as substitutes for some of the cumbrous formal proofs of propositions such as those in Euclid's Second Book; for opinions differ as to the value of strictly demonstrative geometry, both for training and for knowledge. Those teachers who do not regard algebraic methods as proper substitutes for geometric methods might still use them, as well as arithmetical notions, for the purpose of illustrating a proposition or explaining its wider significance. It is the general opinion of the Committee that some association of arithmetic and algebra with geometry is desirable in all cases where this may be found possible; the extent to which it may be practised will depend largely upon the individual temperament of the teacher.

Every method of teaching demonstrative geometry has to face the difficulties inevitably associated with any complete and rigorous theory of proportion. In the opinion of the Committee, not merely is Euclid's theory of proportion unsuited for inclusion in elementary work, but it belongs to the class of what may be called university subjects. The Committee consider that the notion of proportion to be adopted in a school course should be based upon a combination of algebraical processes with methods of practical geometry.

EXAMINATIONS IN GEOMETRY.

As regards examinations in geometry, the Committee consider that substantial changes in much of the present practice are desirable. In most, if not in all, of the branches of mathematics, and especially in geometry, the examination ought to be arranged so that no candidate should be allowed to pass unless he gives evidence of some power to deal with questions not included in the text-book adopted. Such questions might comprise riders of the customary type, arithmetical and algebraical illustrations and verifications, and practical examples in accurate drawing and measurement. The Committee consider the latter of particular importance when the range is of an elementary character; some influence will be exercised upon the teaching, and some recognition will be given to the course of practical geometry that should be pursued in the earlier stages.

ARITHMETIC AND ALGEBRA.

The Committee are of opinion that, in the processes and explanations belonging to the early stages of these subjects, constant appeal should be made to concrete illustrations.

In regard to arithmetic, the Committee desire to point out what has been so often pointed out before, that, if the decimal system of weights and measures were adopted in this country, a vast amount of what is now

the subject-matter of teaching and of examination could be omitted as being then useless for any purpose. The economy in time, and the advantage in point of simplification, would be of the greatest importance. But such a change does not seem likely to be adopted at present, and the Committee confine themselves to making certain suggestions affecting the present practice. They desire, however, to urge that teachers and examiners alike should deal with only those tables of weights and measures which are the simplest and of most practical use.

In formal arithmetic, the elaborate manipulation of vulgar fractions should be avoided, both in teaching and in examinations; too many of the questions that appear in examination papers are tests rather of mechanical facility than of clear thinking or of knowledge. The ideas of ratio and proportion should be developed concurrently with the use of vulgar fractions. Decimals should be introduced at an early stage, soon after the notion of fractions has been grasped. Methods of calculation, accurate only to specified significant figures, and, in particular, the practice of contracted methods, should be encouraged. The use of tables of simple functions should be begun as soon as the student is capable of understanding the general nature of the functions tabulated; for example, the use of logarithms in numerical calculation may be begun as soon as the fundamental law of indices is known.

In regard to the early stages of algebra, the modifications (both in teaching and in the examinations) which are deemed desirable by the Committee are of a general character.

At first, the formulæ should be built on a purely arithmetical foundation, and their significance would often be exhibited by showing how they include whole classes of arithmetical results. Throughout the early stages, formulæ and results should be frequently tested by arithmetical applications. The arithmetical basis of algebra could be illustrated for beginners by the frequent use of graphs, and the practice of graphical processes in such cases can give a significance to algebraical formulæ that would not otherwise be obtained easily in early stages of the subject.

In passing to new ideas, only the simplest instances should be used at first, frequent reference still being made to arithemetical illustrations. Advance should be made by means of essential development, avoiding the useless complications of merely formal difficulties which serve no other purpose than that of puzzling candidates in examinations. Many of the artificial combinations of difficulties could be omitted entirely; the discussion of such as may be necessary should be postponed from the earlier stages. Teachers and examiners alike should avoid matters such as curious combinations of brackets; extravagantly complicated algebraic expressions, particularly fractions; resolutions of elaborate expressions into factors; artificially difficult combinations of indices; ingeniously manipulated equations, and the like. They have no intrinsic value or importance; it is only the mutual rivalry between some writers of text-books and some examiners that is responsible for the consideration which has been conceded to such topics.

GENERAL REMARKS.

If general simplification either on these or on similar lines be adopted, particularly if graphical methods are freely used, it will be found possible to introduce, quite naturally and much earlier than is now the case, some of the leading ideas in a few subjects that usually are regarded as more advanced. Thus the foundations of trigonometry can be laid in connection with the practical geometry of the subject-matter of the Sixth Book of Euclid. The general idea of co-ordinate geometry can be made familiar by the use of graphs, and many of the notions underlying the methods of the infinitesimal calculus can similarly be given to comparatively youthful students long before the formal study of the calculus is begun.

ON THE RELATION BETWEEN MATHEMATICAL RESEARCH AND SECONDARY INSTRUCTION.*

PROFESSOR E. R. HEDRICK, UNIVERSITY OF MISSOURI.

I consider it a great privilege to address the Michigan Schoolmasters' Club, and particularly upon a subject of such import. The breadth of the topic is so great, however, that I feel myself quite unable to do more than point out a few of the many questions which naturally arise, and suggest to you the advisability of their serious consideration. That I should attempt to pass final judgment upon matters of such difficulty, would indeed be presumptuous; my only regret is that I cannot be present in person to learn the views of you who come into such direct contact with the practical side of the questions of which I am to speak.

That the enormous strides made in the study of pure and applied mathematics in the last score of years, must eventually react upon the instruction in the elementary mathematics of the secondary schools and of the first two years of college, seems certain. Just what effect this reaction will have upon such instruction is now very problematical; and without careful consideration and coöperation on the part of earnest teachers throughout the country, the good effects, to which we may reasonably look forward, may be long delayed, or rendered temporarily abortive. On the other hand, it is of vital importance that intelligent teachers should guard against the tendency to overdo any attempted reform, and see that its force is not lost in "fad-isms".

It is for these two reasons that I wish to suggest and explain the following tentative propositions relative to the teaching of mathematics in high schools and in the first two years of college. I sincerely trust that their promulgation will fix attention upon the subject, and that it will provoke a most lively criticism. I would then suggest:—

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*Read by Professor Beman, in the absence of the writer.

(1°) That an effort be made to appreciate and to apply in elementary teaching, the results of modern research in pure and applied mathematics;

(2°) That to this end, to avoid overdoing the matter, the teacher himself should attempt to master those features of the subject which apply to elementary teaching; but that the effect upon the student should be left to the unconscious influence of the teacher's improved points of view, rather than that any radical departures be made immediately, from the material actually taught at present, or from the present methods of instruction;

(3°) That more attention should be paid, however, to the physical and other applications of the subjects taught; and that the various branches should be brought into much closer correlation, or, in certain cases, actually intermingled with one another;

(4°) That a system of laboratory instruction, on a very modest scale, should be introduced gradually; and that boards of education and others instrumental in the arrangement of curricula, be impressed that the advantage to be derived from mathematical exerices over pure class-room drill, is equal to the enormous advantage recently realized in the instruction in physics and chemistry, by the general introduction of laboratory instruction in those subjects;

(5°) That the requirements for admission to college be adapted so as to foster, or at least so as to permit of, such changes in instruction; preferably by the adoption of alternate requirements, which could be satisfied by either method of instruction.

In the discussion and explanation of these theses, it will be enlightening to consider for a moment the history of mathematics in America.

Prior to 1875, aside from one or two illustrous examples, including at least Benjamin Peirce, the advances made on the continent of Europe in the study of pure mathematics, were practically unkonwn, or neglected, in this country. Up to about this time, original work in mathematics by Americans was almost unheard-of, and the knowledge of that done by foreigners was far from general, even among men in the highest position in the American mathematical world.

After about 1875, due to the increasing prosperity and settled condition of the country, more attention began to be paid to the purely scientific side of mathematics, and such a movement, once inaugurated, necessarily bore the fruits of its own logical justification. Today, contrasted with the condition of mathematical knowledge in America in 1875, the situation can fittingly be described as phenomenal and phenomenally encouraging. In almost every large university in the country, and in surprisingly numerous smaller colleges, men are to be found, in ever increasing numbers, whose whole lives are consecrated to the development of pure and applied mathematics; and whose original contributions to the theory commence to be of no mean order, even when compared with the productions of the schools of continental Europe, backed by their hundred years of standing—for modern mathematics is now practically in the beginning of its second century. That these men appear otherwise normal, sane, and appreciative of other sciences, and that they are surely not working for pecuniary gain, leads us to feel

that behind the veil of apparent uselessness and impracticability, must lie an enchanting field of actual reality and fruitfulness, which charms them to their self-imposed tasks, and inspires them in their work.

The American Mathematical Society, non-existant in 1887, now has over four hundred members, bound in a union of fraternity and of enthusiastic sympathy, which no scientific society, at home or abroad, can surpass. This society now publishes two journals, the *Bulletin,* and the *Transactions,* which are recognized, even in Europe, to be among the leading mathematical journals of the world. And at least two other mathematical journals of excellent reputation are published in this country: the *American Journal of Mathematics,* published by Johns Hopkins University; and the *Annals of Mathematics,* published by Harvard University. What is of more consequence, the papers published by these journals are, almost exclusively, the productions of American mathematicians—teachers in our schools and colleges.

Such is, in brief, the history of mathematics in America during the last thirty years, constantly increasing in volume and importance; the last fifteen years cover the history of the American Society; while only in the last five years have the courses in instruction in higher mathematics in our Graduate Schools approached anything like equality with the work in Germany, France, and Italy. It is therefore not surprising that modern mathematical research has not as yet generally affected the elementary instruction in mathematics in American secondary schools; but the time is surely ripe for the serious discussion of this inevitable result.

I propose to discuss briefly a few of the points at which recent investigation touches upon elementary instruction; and, in doing so, I shall make use of ideas which are already prevalent abroad, and of various papers which have recently appeared in American and in European journals, treating the subject of elementary mathematical instruction from a similar standpoint.

Among the questions which arise, the discussion of the axioms underlying geometry and algebra has recently attracted the most widespread attention. I do not agree with those enthusiasts who would force upon the unprepared mind of the young student, ideas of such comparative complexity as those at the basis of these discussions. But it does seem fitting that the *teachers* of mathematics should know and appreciate the excellent work recently done on these subjects, to the end that the teachers themselves be not ignorant of the present state of knowledge, and that they may be able to avoid the formation of wrong conceptions in the minds of the pupils. This can all be done, and without changing the *form* of instruction at all; for, while the matter is not suitable for direct presentation to the student, it is perfectly possible for an intelligent teacher, even though his mathematical education has been restricted to the most elementary college courses, to so familiarize himself with the essential ideas as to avoid forms of expression which would induce wrong conceptions in the student's mind. The study of the axioms of mathematics, in its modern conception, probably started with Gauss, in Germany, about 1800. It was he, and his followers, who showed conclusively the impossibility of proving the axiom of parallels from the

other axioms usually assumed. Even this work was not completed, however, until the middle of the century. The existence and the logical character of geometries in which the Euclidean axiom does *not* hold, and the application of such studies to highly practical problems, are still fruitful subjects of investigation.

But it is even more recently that the greatest light has been thrown on the subject of the axioms of mathematics, and their real significance. Beginning with the work of Pasch, in Germany, and Veronese, in Italy, this newer view found its most brilliant exposition in the now famous treatise on the foundations of geometry*, published in 1900, by Hilbert, in Germany. This book is now fortunately available in English, in a fair translation**; and it should be in the hands of every sincere teacher of geometry—not for his pupils, for they cannot understand its true meaning, but for the teacher's own guidance and information. In obtaining the English translation, the list of corrections, now in preparation, should be secured.

The purposes of such work cannot be explained hastily; it is necessary for one to study in private these apparently trivially simple developments, and to try to discover the real reason for the enormous importance which is now universally attached to them. Let me mention a few points which are now accepted as fundamental canons.

(1°) *The logical consequences of a set of axioms are theorems, which must hold for any set of "things" for which the axioms themselves hold.*

(2°) *In a logical proof, no appeal whatever can be made to the intuition, since the theorems do not depend on the nature of the "objects" employed, except in that the axioms are satisfied.* But *in elementary instruction* intuition should be employed *constantly*: the only thing desired is that the *teacher himself* should not lose sight of the nature of a *proof, in a strictly logical sense.* That assumptions made in elementary instruction are quite allowable, will be seen from No. (5).

(3°) *The only absolutely necessary characteristic of a set of axioms is that the statements made shall in no wise* CONTRADICT *one another.* To show that a given set of axioms does not contradict itself, a *proof* is necessary, since we have no means of judging directly; and this proof is usually very difficult. *Still no proof should be given to the student.* But the *teacher himself* should try to grasp the proof given by Hilbert, that *the ordinary axioms of ordinary geometry are,* in this sense, *compatible.*

(4°) *It is further desirable* (*but in no sense a logical necessity*) *that the set of axioms assumed should* (a) be as *simple* as possible, (b) contain as few *redundancies* as possible, (c) correspond with reasonable accuracy to our *ordinary* conceptions and ordinary intuitive ideas, derived from experience.

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*D. Hilbert, *Grundlagen der Geometrie,* Leipzig, Teubner, 1899, 8 vo., 92 pp.

**D. Hilbert, *The Foundations, of Geometry,* Translated by E. J. Townsend, The Open Court Publishing Co., Chicago, 1902, 8 vo., 132 pp.

(5°) *It is permissible, in elementary instruction, to introduce* AS AN (AXIOM *any statement whatever, which can be proved from the other axioms assumed, i. e., any theorem; or indeed any other statement which does not contradict the original set of axioms, whether or not it is a consequence of them.* This seemingly revolutionary statement is surely justified in the light of these researches, and it should be made clear to every teacher of mathematics. The teacher should of course use proper judgment in assuming theorems in this way without proof, and he should convince *himself,* of course, that the assumptions *are* theorems, or at least, that they are compatible with the axioms. Otherwise their assumption is justifiable on exactly the same grounds as is the omission of the general proof of compatibility.

(6°) *An axiom is by no means a "self-evident truth," nor a "proposition which cannot be demonstrated".* The first of these usual statements corresponds to the notion that intuition is infallible; the second asserts that the system used is entirely free from redundancies. The teacher should realize that *an axiom is merely an arbitrary assumption, which can be altered at the will of the operator;* and that *a set of axioms is any set whatever of such arbitrary assumptions, whose sole necessary characteristic is their compatibility.* We choose from all possible sets, for purposes of elementary instruction, one which is *simple,* and which *corresponds to a reasonable extent with our rough conceptions* gained from necessarily crude experience, for the science under discussion. Care is necessary, logically, only in the proof that the axioms are compatible.

But it is not intended that this short paper should form any complete exposition. The reasoning which leads to the above facts must be carefully gone through before one can render an intelligent judgment. I shall be satisfied if I have directed attention to the subject; for, while the bald statements are at times startling, they are the inevitable result of any thoughtful and intelligent consideration.

I would mention, as enlightening upon the whole question, besides the work already referred to, the following books and papers, which should be in every college library, and accessible to teachers generally:—

Karl Pearson, *The Grammar of Science,* second edition, London, Black, 8 vo., 548 pp.

B. A. W. Russell, *The Foundations of Geometry,* Cambridge University Press, 1900, 8 vo., 201 pp.

Ernst Mach, *The Science of Mechanics,* translated by T. J. McCormack, Open Court Co., Chicago, 1893.

E. H. Moore, *The Foundations of Geometry,* Trans. Am. Math. Society, Vol. 3, 1902.

E. H. Moore, *On the Foundations of Mathematics* (Presidential Address), Bull. Am. Math. Society, Vol. 9, No. 8, May, 1903.

In the perusal of these books and papers, the earnest reader will find many references to other literature, which will prove of great interest, especially if he has a reading knowledge of foreign languages.

But this is merely one point of contact; and there are many others of equal interest, and of equal importance to the teacher in avoiding the installa-

tion of what I might call *false truth* into young minds—truths which require much explanation to make them convey a truthful impression; falsehoods disguised in a cloak of intuitive fallacy.

The question "What is a curve?" is, for example, a much more interesting one than appears on the surface. It is extremely easy to see that a curve cannot, in general, be regarded as the "path of a moving point". While it is best to give some such definition to the young student, it is surely advisable for the teacher, if possible, to familiarize himself with the demonstrated facts, of which I may mention a few:*

(1°) *There are continuous smooth curves which have no tangents at any points; such curves cannot be generated by motion as ordinarily conceived.* It is perhaps even more remarkable that curves exist which *have* tangents at an infinite number of points in any portion, no matter how small, but which *lack* tangents at an infinite number of other points in the same portion. But such curves may have a length.

(2°) *Curves exist which have tangents at every point, and which have no corners, but which have no curvature, no radii of curvature, and no centers of curvature, in any sense whatever.*

(3°) *There are curves which are continuous at an infinite number of points in any portion, no matter how small, but which are discontinuous at an infinite number of other points in the same portion.* Such curves, if plotted in the ordinary manner, would appear to be perfectly smooth, in many cases.

(4°) *There are curves which one can cross without cutting.*

(5°) *There are continuous curves which entirely fill an area.* For that matter, it would be equally easy to construct a curve which entirely fills a portion of space.

This list is not, of course, intended to be complete in any sense, but is merely intended to give a rough idea of the remarkable results to be found in this field. The teacher who feels interested will find an abundance of literature on the subject, in the recent volumes of the journals which have been mentioned; and many references to foreign books and periodicals will be found in these papers themselves.

Again, in the definition of such words as *"motion"*, *"congruence"*, and *"length,"* the most careful consideration is necessary. That "a straight line is the shortest distance between two points", is, for example, a statement whose apparent simplicity covers a multitude of fallacies. For the young student, it is indeed best to give such definitions, faulty though they may be, and to treat motion as a preconceived idea. But it is clearly of importance to the *teacher* to make clear to himself the complex relations existing between these three concepts. Logically, it would perhaps be best to define congruence first, and then to define motion and length in terms of congruence. But whichever order is selected, care must be taken to avoid the use of one of these terms in defining another of them, before it itself has been defined. That this is not usually done, will be apparent from the most hasty examination of the definitions ordinarily given; and it is doubtless *best* to pass over the subject with more or less intuitive explanations, in pre-

*The author regrets the necessity of stating these theorems dogmatically.

senting these motions to a class of young students, especially when it is remembered that the first logically justifiable definition of length occurs in the Integral Calculus. What I have said here is then in full accord with the previous proposal to use the intuition freely in elementary instruction. The teacher, on the other hand, should not be ignorant of the fallacies involved in the ordinary argument: (a) that the straight line has no inherent property of being the *shortest* line, until we have defined what we shall mean by the word "length;" (b) that there are reasonable definitions of length, which lead to practical results of value, for which the straight line is *not* the shortest distance between two points; (c) that our notion of ordinary motion is susceptible, besides the extraordinary changes involved in the above geometries, of simple restrictions, such as the elimination of rotation, which lead to the most beautiful results; or of extension, as by the introduction of reflection, dilitation, and so forth, under the category of motions; (d) that the idea of motion may be derived logically from that of length; (e) that the axioms of congruence are at the basis of the ideas of length and motion; and (f) that a strictly logical definition of all three terms may be arrived at by means of the Integral Calculus, the length being defined by means of a definite integral. These are of course only a few of the many interesting and valuable facts. That geometries exist in which the shortest lines are straight lines, but which do not coincide with ordinary Euclidean geometry, has been known for many years, and the Cayley-Klein geometries offer the most beautiful examples of this type. What forms have been given to these developments in recent years, may be traced in the papers read before the American Mathematical Society which are reported in the Bulletin, in papers published in the periodicals already alluded to, and in papers to which references will be found in the latter.

In this connection the treatment of ratio and proportion usually given in secondary schools naturally comes into question. The teacher is recommended, if he reads German, to study the elegant and extremely simple presentation given by Mollerup, in an article in the *Mathematische Annalen* for 1902, which can be found in the University library.

Another very practical conception is that of number; and we find that many common assumptions are invalid. Is there a least number greater than zero? How shall we convince ourselves of its non-existence? Are there any two numbers, such that no multiple of the smaller exceeds the larger? Curiously enough, there might be, in the systems of axioms usually assumed for elementary arithmetic; and it is necessary to exclude this possibility by explicit statement, in the form of an axiom, if we wish to avoid such extraordinary and undesirable combinations: that this *is* advisable appears when we consider that motion, as ordinarily conceived, would be impossible in a geometry in which such quantities were allowed to occur. The avoidance of a bad use of the words "infinity", "infinitesimal", "infinitely small", and so on, becomes imperative, under the circumstances; and the teacher will surely lead the student to the most vicious misconception, unless he is very careful to make the whole matter clear in his own mind, and to choose his language at all times with the utmost care, when referring to these delicate subjects.

It should be borne in mind constantly that the above axiom, known as Archimedes' axiom, though too nice to be introduced into elementary instruction, is really at the basis of all arithmetic and geometry; and the astounding properties which an arithmetic, or a geometry, may have, if this axiom is expressly omitted or violated, should prove an effective warning against its neglect by teachers, in their expressions before students. It is not uncommon, for example, for teachers of geometry to refer to infinite quantities in such a way as to imply a direct violation of this axiom, and this before students whose minds are in the formative stage; while the references sometimes made to infinitesimal quantities by teachers and even by books on the Calculus, seem to denote an utter disregard of its fundamental character.

Is it possible to distinguish between the number of positive integers and the number of positive fractions? It is indeed singular that it is not. But we *can* distinguish between the number of positive integers and the number of positive numbers as a whole (including the incommensurable numbers). But, again, there is no means of distinguishing the number of points on a line (i. e., the whole number of numbers) from the number of points in a square, or from the whole number of points in a plane; for these two sets of points can be paired off, one to one, so that each point of the line is mated with one point of the plane, and conversely. These are, however, merely isolated questions, which are suggested only to inspire curiosity and inquiry, on the part of any to whom they may be unfamiliar. Nevertheless, precisely these questions, and other similar ones, are coming to play a rôle in modern mathematics which is fundamental, and almost preponderant.

I have tried to make clear my two first propositions: that it would be well for the teacher to familiarize himself with the results of modern mathematical research as far as possible; and that in so doing, it is not that the direct instruction to the student would or should be altered in *form,* but that the teacher's own increased appreciation might reflect indirectly upon his teaching *truer conceptions of things as they are.* I have not touched upon such important subjects as limits, and infinite series, because a study of these subjects would be of less direct influence upon elementary teaching, the mastery of their fundamental principles would involve a more thorough training than I have wishd to assume, and ignorance of them would be less likely to lead to inefficient teaching in secondary schools. On the other hand, I have laid speciai stress on the matter of axioms, on account of its importance, and on account of its present accessibility in a form which the average teacher can master.

In addition to the suggestions already made, I would suggest to any teacher interested in improving his knowledge or his teaching, two methods of doing so, aside from the study of books. In the first place, there might well be, on any teacher's table, a copy of some reputable periodical magizine or journal devoted to Mathematics. This should be, however, a journal in good standing, and not one devoted to the solutions of trivial problems. At least one such is, fortunately, available: the *Annals of Mathematics,* published quarterly at Harvard University, by a board of editors from different universities. Some of the articles which appear are readable without any advanced

knowledge, and others will inspire the reader to further investigation and study. This is the only American mathematical magazine in which elementary work appears, which can be generally recommended; but *it* can be recommended to any serious teacher whose training includes at least two years of college work. For the other American journals to which I have referred, as well as for foreign books and periodicals, the average teacher might well rely upon the University library.

Another means which suggests itself at once, is close alliance to the University; and this will recommend itself to the members of the Schoolmasters' Club. Attendance at the meetings of the Club, and use of the library at such times, to clear up difficulties which may have arisen in the interim; attendance at the Summer School; or, better still, if possible, an occasional whole year spent at the University, will help the teacher surely and remarkably in his work.

I will try to be as brief as possible in the discussion of my remaining theses. They regard the student rather than the teacher.

It is not a new idea that mathematical instruction should be illustrated by practical problems, drawn from Physics and from other sciences. In fact, every branch of mathematics has had its *origin* in problems of an *extremely* practical nature. But the separation which was effected in the early part of the nineteenth century, between mathematics and its applications, has been carried to such an extreme that the studies of a purely mathemathical nature and those applications pertaining to Physics, have been wholly separated, not only in the secondary schools, but also in our colleges and universities. From the standpoint of the student this state of affairs is extremely deplorable. It leaves the study of mathematics *dry, unpractical,* and often *meaningless,* to him; and, whether he is to go on in mathematical studies, pure or applied, or whether he is to leave the subject permanently, it is of equal importance that he should be made to see the bearing of the subject, and its real significance in its applications. At just this time it is worth the effort to try to effect this change, the advisability of which is generally admitted, in a greater or lesser degree. For the leading minds in mathematics, physics, and engineering are just now giving their most thoughtful attention to a similar necessity in advanced work. Poincaré, himself a mining engineer by training, is now the acknowledged leader of pure mathematics in France; and his papers in the journal "L' Enseignement", and in the Transactions of the Paris Mathematical Congress,* demonstrate conclusively the practicability of this change, and its advisability from the standpoint of the future engineer, as well as from that of the future mathematician, or, indeed, from that of the student temporarily engaged in mathematical study.

The most extreme agitation at present is in Germany and in England. In Germany, proposal after proposal each meets its counter-proposal in

*For precise references, here and later, see Moore, l. c., Bull., Vol. 9, No. 8, May, 1903, pp. 492, etc. See also Poincaré, La Science et L'hypothése, Paris, Gauthier Villars, 1903.

schemes for the revision of elementary and college instruction in mathematics—from engineers on one side, and from mathematicians on the other. The recent files of the "Bericht der Deutschen Mathematiker-Vereinigung", and the reports of the metings of the German Association of Engineers, teem with discussions which, although tinged with some local color, cannot fail to be illuminating and helpful.

What *can* be done is shown most plainly in the work and in the writing of John Perry, Professor of Mechanics and Mathematics at the Royal College of Science in London, and Chairman of the Board of Examiners of the Board of Education, in mathematical subjects. His work in his official capacities, and in connection with several committee reports on the improvement of mathematical teaching, as well as his actual experience in teaching mathematics of no mean order, to mechanics and apprentices in the London night schools, and still more his books and papers resulting from these experiences, are highly suggestive and supremely original.* Especially does his "Calculus for Engineers" show possibilities in such a subject for wide divergence from present methods of presentation, with reasonable hope for great improvement. While we cannot unhesitatingly approve all that Perry does or says, and while such changes as are to be made, must be carried out slowly in order to be permanent, yet his ideas may certainly be studied to advantage, and they are fortunately accessible in his papers, many of which are to be found in the library.

My latter theses are so ably maintained by Professor Moore in his Presidential Address, that I would best repeat his very words, were I to enter upon a detailed discussion of them. In fact, to sum up the results of his reasoning, we would be led to practically restate these propositions, with considerable amplification and appropriate explanation.

Let me attempt to sketch such a resumé. In the first place, that elementary mathematical instruction should find its logical explanation in examples drawn from practical physics and mechanics. There seems to be no doubt that this is actually feasible at present, if teachers and authors of text-books would unite to secure the desired end. That Physics and Mathematics should eventually be consolidated, is one of the propositions advanced by Professor Moore; and, while we cannot hope for this result immediately, it does seem possible and advisable that much of the matter and some of the examples now included in High-school and Freshman college Physics, should be incorporated in text-books and in courses in High-school mathematics. At least the student should be relieved of the idea that truth in one room, under one instructor, is essentially different from related truth taught across the hall, by another; *such* is, and has been, the extreme divorce of Mathematics from Physics in our High-schools, and of Mathematics from Physics and Engineering in our colleges and universities.

It has been suggested that such a reform would necessitate the omission of some of the material now given; and it is doubtless true that such a pro-

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*Again I would refer the reader to the bibliography given by Professor Moore, in footnotes to his Address.

gramme as that proposed by Professor Moore, if carried out in full, would cause some abridgements. It would seem, however, that such sacrifices would be more than compensated for by the improvement in the students's general grasp of the subject, and that a net gain could be realized. It is very doubtful to my mind, for instance, whether the student gains much from the *logical* part of *solid* geometry. The logical forms have all occurred in the teaching of *plane* geometry, and hence the processes used in the logical deduction of theorems are practically, for educational purposes, a needless repetition. If *plane* geometry could be assigned more time, at the expense of *solid* geometry, so as to afford time for the introduction, into plane geometry, of a few physical problems, and of some of the laboratory work of which I shall speak, I believe the student would *learn more geometry* in the end. Of course I would not neglect that great merit of solid geometry—its development of the space intuition, and of the ability to project a plane diagram into a space figure, and conversely. But I believe that the teaching of solid geometry could be *stripped down to almost nothing else,* by assuming most of its theorems by an appeal to the intuition, which needs practice if not development, and by emphasizing what is *new* in solid geometry, *only.* The general notions of projection and the general space relations, can be taught without the accompaniment of the petty logical processes which usually crowd the first part of a solid geometry text. I would propose even more thorough drill in these things, with even additional matter, taken from the elements of descriptive geometry and of the theory of perspective, accompanied by the drawing of diagrams, and the construction of actual models. With this, much attention should be paid to such new and important general principles as that of Cavalieri; which, as far as I know, is to be found in only one American High-school text—that of Professors Beman and Smith.

The same general remarks apply to the teaching of Algebra. Doubtless some of the matter now taught could be sacrificed, if necessary. In particular, the treatments of series, permutations and combinations, simple and compound interest, and so on, might be omitted. If we could introduce, in their stead, algebraic problems drawn from actual problems of physics, mechanics, and geometry, a gain might be effected in the student's total algebraic power. And now that the cross-section paper of analytic geometry is in common use for diagrams in mechanical machines of all sorts, by railroad offices, by insurance men, by even the daily newspaper, it seems certain that a high school student could grasp the use of this convenient mode of expression, as applied to practical uses and to practical problems, if not as a graphical means of studying equations and their roots. Perry's essay on "Square Paper" would be helpful, in such a connection, in freeing analytic geometry from its incubus of artificial names, words, and signs.

What I have said naturally leads to the idea of a mathematical laboratory, for the suggestions already made would be quite sufficient for a beginning. What with the drawing of accurate figures, and diagrams of solids, supplemented by some practice in practical draughting; with the construction of actual models in paper, wood, tin, plaster, and other available material: with the metrical experiments of weighing and otherwise measuring solids

and planes; with the construction of graphical time-tables, physical laws, statistical curves, and other similar figures, on cross-section paper; all the time and means at present obtainable for the purpose, could be profitably spent. I believe that the outlook for a mathematical laboratory in the high school is at present actually brighter than was the outlook for a high school physical laboratory, twenty years ago, not to speak of chemical, biological, and other laboratories, which are in common, and highly successful, operation in our High-schools today. What the development of the High-school mathematical laboratory might be, and how beneficial in its effect on the student's grasp of the subject, may be guessed from the known results in other subjects, if it is not inherently apparent.

The same general ideas apply, with added force, in fact, to instruction in colleges. Illustrations and applications drawn from other sciences are, indeed, not wholly lacking, but they might be made vastly more effective and helpful, by increasing their number and their practicalness. Especially is this true of the Calculus, which so sadly often leaves the student with the notion that mathematics is a dreamer's raving. Might not more time be given to the applications of the Calculus to Mechanics, and less to the traditional "applications" to the theory of curves and surfaces? Is not the idea of a derivative more clearly illustrated by a *velocity* than by the slope of a curve?—at least it was in this way that Newton conceived of it, when he invented the Calculus. And can there be any comparison between *acceleration* and *curvature* as a simple illustration of a second derivative?

But it was not my purpose to touch upon the instruction of mathematics in colleges, so much as to urge reform in our secondary institutions. As for the laboratory idea, I will merely mention that modest laboratories have already been started at Yale and at Chicago, at least. Let us hope for their success and development, and for the gradual introduction of laboratories in all large colleges.

Finally, it is apparent that such changes cannot be made by teachers in secondary schools without the co-operation and assistance of the University. Texts must be written, the use of which is at least not fatal to such a course; but these will come in time; our recent text-books show enormous improvements in precisely these directions. Teachers must be trained to understand the meaning and the purpose of the proposed reform; but our present university instruction is sufficiently literal to give hope that a beginning might be made at once. The only serious difficulty in the way of an immediate beginning is the obvious necessity of a change in college entrance requirements.* It is clear that an alternate system of examinations would be needed, which would admit of either method of instruction. But this change *must be made at once,* if any considerable alteration in our High-school Curriculum is to be fostered. That such a change would be advisable is not the isolated

*In this connection mention should be made of the recent Provisional Report of the Committee of the American Mathematical Society on Definitions of College Entrance Requirements in Mathematics, which has been sent to the members of the Society.

opinion of the writer, but is maintained by all those who look for improvement in secondary instruction along the lines which I have suggested; and I trust that those in authority in all of our larger colleges, will see their way to a *gradual* change in this direction. It is particularly desirable in the State of Michigan, that the stimulus for improvement should come from the University, on account of the ascendancy of the University over the secondary schools of the state, and on account of the intimate relations existing between the University and the Schoolmasters' Club. Should the members of the Club coöperate with the University authorities to promote and encourage such reforms as those which I have indicated, I believe that a marked improvement would be felt immediately in the instruction in mathematics, throughout the secondary schools and the colleges of Michigan.

I would reiterate, however, that my statements are not intended to be a final *dictum* on the subject. But that some such reforms are inevitable, and that we must either bend or break, under the pressure of their necessity, seems certain. I shall feel highly gratified if my tentative remarks only lead to serious discussion, and to awakened interest on the part of the members of the Club.

MATHEMATICS IN THE SECONDARY SCHOOLS OF NEW YORK CITY.

CLIFFORD B. UPTON, HORACE MANN HIGH SCHOOL, NEW YORK CITY.

A visitor to the busy metropolis who expects to find a thoroughness and enthusiasm in the teaching in the secondary schools which corresponds to that in the commercial life of the city will not be disappointed. He will discover school work here which is in all respects equal if not superior to that of any other city in the Union, and will leave with the feeling that much of value has been gained from his observations.

Greater New York, which is a single municipality formed by the consolidation of New York, Brooklyn, Long Island City, and several adjoining towns, has in all twenty public high schools which have a combined attendance of eighteen thousand students, about two-thirds of the total number attending all the high schools in Michigan; five thousand more students are found in the private secondary schools, all of which do excellent work and which also must be visited if one would become thoroughly familiar with the teaching in the city. It is readily seen that it requires no small amount of time to visit but a single department of so large a number of schools, yet an examination of the typical schools will give one a just estimate of the entire system. Having spent one week visiting the mathematical departments of the most prominent public and private high schools in New York and Brooklyn the writer will attempt to give some idea of what is being done in them in the teaching of secondary mathematics.

NEW YORK CITY

Year of Course	Horace Mann High School (Private)	New York High Schools (Public)	New York Commercial High School (Public)	Dr. Sach's Collegiate Institute (Private)	Chicago High Schools (Public)
I 1st sem.	alg. 5	alg. 5	alg. 4	alg. 2	alg. 4
I 2nd sem.	alg. 5	alg. 5	alg. 4	alg. 2	alg. 4
II 1st sem.	pl. geom. 5	pl. geom. 4	pl. geom. 3	pl. geom. 2 alg. 3	pl. geom. 4
II 2nd sem.	pl. geom. 5	pl. geom. 4	pl. geom. 3	pl. geom. 2 alg. 3	pl. geom. 4
III	2 1 *alg.-geom.* 3 2 1 *alg.-geom.* 3	pl. geom. 3 alg. 3	pl. geom. 3 alg. 3	pl. geom. 3 alg. 3 pl. geom. 3 alg. 3	*alg.* 4 *sol. geom.* 4
IV	*trig.* 3 *sol. geom.* } 3 *alg.* }	*sol. geom.* 4 *alg.* or } 4 *trig.* }	*sol. geom.* 4 *trig.* 4	pl. geom. 3 alg. 3 pl. geom. 3 alg. 3	 *trig.* 4
	32	32	28	38	28

The numbers after each subject indicate the number of recitation periods a week.

The length of the recitation period in each of the above New York courses is 40 minutes.

The numbers under each course indicate the number of recitation periods per week for one semester which would be equivalent to the total time spent reciting mathematics during the four years.

Subjects in italic are elective.

The course of the Chicago High Schools is added for comparison.

The course of study in mathematics first attracts our attention. It is the same for all the twenty public high schools of greater New York, except the manual-training and commercial high schools, and even in these the variation from the regular course is very slight. Furthermore, equal amounts of algebra and geometry are covered in the various schools during each semester, the exact requirements being given in a syllabus recently prepared by the superintendents, after consultation with the heads of the mathematical departments. Referring to the tabulated course of study it will be noticed that plane geometry occupies all of the second year and the first semester of the third, while solid geometry is given the first semester of the fourth. The syllabus just mentioned requires in the second year the first four books of plane geometry plus a minimum of three hundred exercises, and in the first half of the third year the completion of the subject plus a minimum of seventy-five exercises. In algebra simultaneous quadratics must be finished in the first year, while in the third year the first year's work is reviewed, and ratio, proportion, series, and the binomial theorem are added. In the mathematics of the fourth year the student is prepared for his college entrance examinations and is given practically what he needs for the particular college he wishes to enter; he may have solid geometry and plane

trigonometry or even advanced algebra, if he happens to be preparing for some technical school. The public high schools can easily satisfy the various demands in the senior year, as each large high school has from ten to fifteen teachers of mathematics, with each course divided into several sections.

The course of the Horace Mann School is a typical private school course. Plane geometry is finished in the second year, and is reviewed one hour a week during the third year, in connection with a two-hour course in algebra; the fourth year is similar to that of the public high schools. The other courses explain themselves. Dr. Sach's school is especially strong in mathematics, and the course is of interest in showing what division is made to carry algebra and geometry side by side during the last three years. A general examination of all the New York courses will now show the following important facts:

(1) There is an almost absolute uniformity in all the courses of both public and private schools.

(2) The work is extended over the entire four years, so that no semester is without its mathematics. The work is thus constantly kept fresh in the student's mind, and this without any disturbance in the sequence of the course.

(3) A requirement of three years work in mathematics from all students in the public high schools.

PUBLIC HIGH SCHOOLS OF MICHIGAN

Year of Course	Detroit	Jackson	West Saginaw	Ann Arbor	Kalamazoo	East Saginaw*
I	alg. 5 alg. 5	alg. 5 alg. 5	alg. 5 alg. 5	alg. 5	alg. 4 alg. 5	*alg.* 4 *alg.* 4
II	alg. 5		alg. 5	alg. 5 alg. 5	alg. 5	2 3 *alg-geom.* 5 2 3 *alg-geom.* 5
III	pl. geom. 5 pl. geom. 5	pl. geom. 5 pl. geom. 5	alg. 2½ pl. geom. 5 pl. geom. 5		geom. 5 pl. & sol. geom. 5	*geom.* 2 *geom.* 2
IV	*sol.geom.* 2½ *trig.* 4 *alg.* 2½	*sol. geom.* 5 *trig.* 5 *alg.* 5	sol. geom. 2½	geom. 5 pl. & sol. geom. 5 *trig.* 5	*trig.* 4	*alg-geom.* 3 *trig.* 2 *alg-geom.* 3 *trig.* 2
	34	35	30	30	28	32

*East Saginaw has required work in algebra in the seventh and eighth grades.

Subjects in italic are elective.

For the sake of comparison several of the typical Michigan courses have been added. No longer can it be said that the chief difference between the courses of study in the East and the West is that the East devotes one year

to plane geometry while the West devotes one year to both plane and solid; the East has added solid geometry, although as an elective, and the West is giving more time to plane. Detroit, Jackson, and West Saginaw each devote the entire third year to plane geometry, putting solid geometry in the fourth, while Kalamazoo and Ann Arbor still cover both plane and solid geometry in a single year. This leads us to make a general examination of the Michigan courses with these results:

(1) There is no general uniformity in the courses, although Detroit, Jackson, and West Saginaw are quite alike.

(2) There is no school which spreads the work over the entire four years, except East Saginaw. In that city this result is attained by dividing the subjects to such an extent that a student changing from one school to another before graduation would be placed at a considerable disadvantage.

The numbers under each course of study indicate the number of recitation periods per week for one semester, which would be equivalent to the total amount of time spent reciting mathematics during the four years. It is thus seen that some of the Michigan schools spend more time upon mathematics than either the New York public schools or the Horace Mann School, and still do not secure the New York advantages of continued sequence and uniformity. The course of the Commercial High School of New York is an excellent example of what may be done in the distribution of the work over the course, using no more time than the minimum of any Michigan school.

The extension of the work through each semester of the course is secured by placing plane geometry in the second year. This plan is so simple as to raise the question as to whether there is any reason for not placing it there. By starting slowly, and devoting a year or even more to plane geometry, a student can take it up in the second year with an interest very much greater than that with which he would study algebra in that year, and in addition the plan gives him a good general mathematical training before commencing the study of physics. This would leave the third and fourth years for an arrangement similar to that in the New York courses.

With much interest the writer has watched the courses in Michigan for several years and it certainly seems that they are in a stage of transition. From a single year's work in plane and solid geometry in the fourth year they are changing to a whole year of plane gometry in the third year and a semester of solid geometry in the fourth, with a general tendency to extend the work over each semester of the entire four years. Uniformity and division seem to be the goal, and the writer firmly believes that a few more years will find all of the Michigan courses uniform with those of New York and Chicago.

The teachers of the secondary schools in New York are an interesting body; their scholarship is high, their experience large, and their personalities are especially attractive. There are three grades of teachers in the public high schools, and before election a teacher must possess the qualifications of the grade for which he applies in addition to passing a very rigid

examination in mathematics, the methods of teaching it, and the science of education. The requirements of the different grades are as follows:

The head of the department, called first asistant, must be a graduate of a recognized college or university, and must have had at least one year's satisfactory post-graduate work, besides five to seven years of successful experience in teaching in secondary schools or colleges. His salary for the first year is $2,500 with an annual increase of $100 until a maximum of $3,000 is received.

The second assistant must be a college graduate and have had at least two years of successful experience in teaching in secondary schools or colleges. The first year's salary is $1,300 with an annual increase of $110 until a maximum of $2,400 is received.

A teacher of the junior grade must have a college degree and have completed a satisfactory pedagogical course of at least a year, all in addition, of course, to the above mentioned examinations. The salary starts at $900 with an annual increase of $50 until a maximum of $1,200 is reached. All the salaries quoted are those of men, the women receiving salaries correspondingly high, though a little less in amount.

What is the result of these requirements and these salaries? There can be but one result and we find that here. The teachers are thoroughly prepared for their work, and, in addition, are broad-minded, liberally cultivated men and women. They are teachers in every sense of the word. In the private schools the faculties are equally competent, and men with master's and doctor's degrees are found in almost every such institution.

It is of interest to note in this connection that New York City now has the best facilities of any city in the country for the thorough preparation of teachers of mathematics; more extensive courses in the pedagogy and history of mathematics are offered than in any other city, while certain collections of original sources here, which bear directly upon the teaching and history of mathematics, are now the largest and most complete in the world.

As to the spirit of the work and methods of teaching much can be said. It is just the spirit that one would expect from teachers with the education, training, and personality required by the New York Board of Education.

First of all, thorough, rigid mathematics is taught. Every detail is thoroughly emphasized and the student is expected to master it. There is an excellent appreciation of a student's needs, while mistakes and difficulties are skillfully cleared away. There is a constant requirement of clear thinking, with exact and concise statement, while carelessness is not tolerated for an instant. But this emphasis of the long recognized disciplinary features of mathematics is not all that is found; the distinctively newer life and scientific spirit which have now come into the teaching of secondary mathematics are discovered to quite an extent, and give evidence of spreading very widely throughout the city within a short time.

In algebra the syllabus in mathematics just prepared for the public high schools, advises the teaching of detached coefficients, the remainder theorem, the treatment of quadratic equations immediately after factoring, and the checking by short methods of not only all the fundamental opera-

tions and factoring, but also of the roots of all equations. Many of the teachers have been doing these things for some time and have also used graphs very freely in the study of equations.

In geometry it is gratifying to see the interest taken in exercises, the syllabus requiring that at least 75 be taken up with each book of geometry, and some of the contributors to the syllabus even favored requirements and suggestions as to methods of attack for these exercises, although this feature has not as yet been inserted. However, the fact exists that many of the teachers have already made a good beginning in presenting general methods of attack, and an extension and requirement of this practice is soon looked for.

The writer found several teachers who also introduced choice bits of the history of mathematics to make the work more real and interesting.

So anxious are a few of the teachers to improve their work, that they are trying the no-text plan in geometry and the individual or laboratory method for algebra, and, it is claimed, with excellent results. The great majority, however, are following the plan which long experience has proved the best, i. e., of following a good text and carrying on a live recitation.

Another commendable thing is that there is no uniform text which every school must use; the Board of Education furnishes a list of 42 of the best American algebras and 40 geometries, from which each high school may select the texts it wishes. It is also of interest to add that several of the most prominent private schools have lately discarded the older texts for the more rigid and modern books.

The above are not theoretical statements but are the results of the writer's personal investigations in the schools themselves.

So far the general spirit of the work in the public high schools has been discussed. A few words may now be in place concerning the work in the largest and most prominent private school in the city, the Horace Mann School. This is the school of observation of Teachers College of Columbia University; it is supported and controlled by Teachers College and is a part of the Columbia University system. It has an attendance of a thousand students, about one-half of whom are in the High School. It is a private day-school, and a high tuition is charged, but it is not a school for general practice teaching, Teachers College maintaining a free school in another part of the city for that purpose.

The mathematical department of the high school is supervised by Dr. David Eugene Smith, professor of mathematics in Teachers College, and it is in this high school department that the spirit and methods of the pedagogical courses given by him in Teachers College are carried out. The spirit of the teaching is entirely modern, and all of the real improvements in the teaching of mathematics are here put into practice. It is not a department of fads but a place where methods of teaching are used which the history and pedagogy of mathematics have proved to be thoroughly sound.

All of the rigorous teaching noted in the public high schools is here found, and in addition all of the usable modern notions are taught with great success.

In algebra the students are given almost their first ideas of formal mathematical reasoning, and find that the subject is made up of definite principles. They better appreciate the meaning of the new kinds of number in algebra because they have been given parts of the history of our interesting number system. When an expression to be factored does not fall under one of the ordinary types, they quickly and intelligently apply the remainder theorem and they know their results are correct because their work checks, an answer book being an unheard of thing; while the usual maze of quadratic equations is clearly seen to be nothing but factoring. It does not require an extra amount of time for this modern work, but on the other hand, it is found that the interest in it rather facilitates than retards the speed over the required ground. This work is all done in a thirty-three weeks' school year by students of only average ability who all carry heavier programs than the average public high school student.

In geometry a like interest is found, and this too in the second year of the high school course where experience has shown that geometry can readily be taken up. Principles of wide application are readily grasped, such as those of continuity and the law of converse, and the students delight in generalizing a figure or in proving a converse theorem by means of the law. General methods of attack are early given to the student, and the exercise work is full of enthusiasm as a result. The history of geometry is frequently found to be a means of adding intense interest to the work, the boy knows why in elementary geometry he uses only the straight edge and compasses, and why it is useless for him to attempt to trisect an angle. Here, too, it is found that the work is made lighter rather than heavier by an appeal to the modern methods.

Another source of inspiration to the students is the high school mathematical library. Here are found books on mathematical recreations, the best histories of mathematics in English, the classic texts in algebra and geometry, besides many little books, like "Flatland," which make one feel that mathematics is not only a very interesting but a really fascinating subject.

The department of mathematics also possesses a complete set of the latest German models for illustrating the theorems in solid geometry. These are, however, used with considerable discretion, and are not allowed to rob the subject of its value as an exercise for the imagination.

The teachers are enthusiastic and get their enthusiasm from the head of the department and from their acquaintance with the very best literature upon the subject. All the leading foreign and American texts are available and are consulted. The work is thoroughly systematized and there is a general uniformity in method and spirit throughout the department.

In conclusion it can be said that the teaching of secondary mathematics is exceptionally good in New York City and this excellence is not accidental, but the result of natural causes. A good course of study, and salaries sufficiently high to obtain thoroughly prepared teachers must produce good results. And further, with the awakening to the fact that not only a thorough academic training, but also a strong course in the pedagogy of mathematics is the necessary training for a teacher of high school mathematics we shall find our teaching taking on a new life.

TO WHAT EXTENT SHOULD ARITHMETIC, ALGEBRA, AND GEOMETRY BE TAUGHT TOGETHER?

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A text for this paper may be found in one of the recommendations of the mathematical conference of the Committee of Ten, viz., "The course in arithmetic should be at the same time abridged and enriched." Deferring the question of abridgement, the more immediate topic will be the enrichment of the course in accordance with the demands of the subject-matter of the great science of mathematics and of the nature and development of the child.

It would be interesting to trace the origin of the present arrangement of the mathematical studies of our primary and secondary schools,—first for eight years repulsively and fatally large portions of arithmetic in the American acceptation of the word, then for a certain period algebra as a study entirely distinct from the preceding, then demonstrational geometry quite as distinct, each isolated from and neither helping nor helped by the others. Was it due to the limited attainments of the instructors in those branches? Or was it in obedience to the commercial spirit of the communities that the mathematical portion of the course pursued by the majority of children should be devoted to those topics popularly supposed to be helpful in business transactions, but now admitted to be of very slight value either commercially or mathematically? They not only fail to bring about that quickness and accuracy in computation essential to success in either business or student life, but effectually kill off any fondness for mathematical study or powers of clear and exact reasoning.

It is obvious that the foregoing classification is highly artificial. The algebra of our secondary schools is esentially the same as the arithmetic which goes before, differing only in the generality due to the employment of the literal notation and the introduction early in the process of solution a symbol representing the unknown desired number. A more scientific classification would seem to be the following: Arithmetic, Geometry, and beyond these Analysis. Arithmetic is the science—and, like all the others, the art as well—of constant numbers, discrete at first, later also continuous number. It includes the elementary arithmetic of the first four fundamental operations, the literal or general arithmetic commonly called elementary algebra, and higher than these the theory of numbers and the theory of number systems. Geometry concerns itself with form and space relations and includes observational, constructive, demonstrational Euclidean and non-Euclidean, projective, vector, and analytic or coördinate geometry. The term Analysis is used to include all that nongeometric mathematics which results from the introduction of continuous variable number, beginning with the calculus, the threshold to all higher mathematics.

In no branch of higher mathematics do we find ourselves concerned exclusively with one of the two latter classes, but continually use processes and illustrations taken from both with the utmost freedom. The form side and the number side are but the two aspects of the one science of mathematics. This mutual dependence and helpfulness are equally characteristic of the elementary branches. Arithmetic in its beginnings has to do not with abstract but with concrete numbers. It grows by means of and concerns itself very naturally with geometric relations and measurements. On the other hand geometry at once depends on and enriches the arithmetical and algebraical processes and results, while elementary algebra is, as I have said, a generalization of the other two and affords an invaluable mechanism to aid in their investigation.

Not only is all this true from the standpoint of the nature of the subjects themselves. It accords equally with the needs of the developing mind. If we assign to either arithmetic or geometry the earlier place in the growing child's mind, it must be to the latter. Forms of objects constitute one of the first and most fruitful and abiding concerns of the child's mental activities. He learns to count as he learns to distinguish between different objects, and the relations between the parts of objects afford an easier and more interesting occupation than the relations and combinations of abstract numbers. Even when the child has advanced from the observational to the reasoning stage, how many high school seniors can either comprehend or give the demonstration of a theorem in algebra as understandingly and successfully as that of one in geometry?

In view of this intimate interrelation between arithmetic and geometry, and because they form but two aspects of the science and art of mathematics, it follows that they should be developed side by side in a course of instruction pretending to educate the whole child. This should, of course, be done with due regard to the peculiar rights and values of each. For example, danger lurks in the too complete substitution of the numerical method of demonstration for that which is purely geometric: The Pythogorean proposition, for instance, may be demonstrated by a purely geometric method or by a substitution of the symbols representing the number of units of length in the sides and the employment of the algebraic theorem of the square of a binominal. In the report of the Committee of Fifteen, in an argument against the early study of geometry, the one method is mistaken for the other.

Concrete or observational geometry ought then to be given a place early in the curriculum and throughout. The chief ends to be secured by early geometrical teaching are accuracy of observation and definiteness of imagination. These uses of geometry have been strangely neglected by both friends and foes of this intellectual training, who have considered only the continuity of thought and the consecutive dependent argument. But the powers of perception and of imagination, or conception, are of quite as great importance as those of reasoning. They give us the basis of facts without which reasoning is vague and worthless. The early study of the child, therefore,

while seeking to develop his ideas of space and time, must do so by training him to rapid and exact observation, clear and definite conception.

This observational or inductive side of mathematics may well be emphasized. It is common for non-mathematical writers to consider all mathematics as of the same nature as Euclid's Elements, starting from certain assumed definitions and axioms and proceeding by connected deductive reasoning to a final conclusion. Says Professor Huxley: "Mathematical training is almost purely deductive. The mathematician starts with a few simple propositions, the proof of which is so obvious that they are called self-evident, (sic!) and the rest of his work consists of subtle deductions from them." And again: "Mathematics is that study which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation."

Lagrange, than whom no higher authority could be quoted, has expressed emphatically his belief in the importance to the mathematician of the faculty of observation. Gauss has called mathematics a science of the eye. Riemann has written a thesis to show that the basis of our conception of space is purely empirical and our knowledge of its laws the result of observation. Sylvester, in an address before the British Association, cites many notable examples of analysis discovered by observation and established by induction and verification, the deductive proof following long years afterwards.

From this argument we must not conclude that the mathematical laws should be allowed to remain standing on an empirical basis, nor infer that mathematics affords the best training in observation and experiment. The biological and physical sciences are undoubtedly much better adapted to the latter purpose, while the inductive stage of mathematical study must gradually pass over into a demonstrational one, increasing in rigor as the mind gains in power of connected, exact reasoning. The present contention is that this gradual development should continually extend over both the arithmetical and geometrical sides of the science, so that both may keep pace with the other mental activities of the child to afford an even well rounded development. Such a course does not consist in an attempt to memorize or discover independently demonstrations for the theorems of Euclidean geometry, nor is it satisfied by including in our arithmetics numerical exercises in mensuration. The first would be time and endeavor worse than wasted in the lower grades. The latter affords a valuable enrichment of arithmetic, but little more. The study of the properties and relations of geometric forms by means of close observation, oral and written descriptions, and constructions will afford abundant material for the pursuit of geometry for itself. Time for it can well be spared from that now devoted to arithmetic, without sacrificing the true interests of that subject.

As to elementary algebra, i. e., literal arithmetic and the use of the equation and the symbol for the unknown quantity, abundant appropriate and valuable opportunity is afforded for its introduction whenever the pupil evinces sufficient ability to generalize. Thus the laws of addition, subtraction, multiplication and division and the exceedingly simple relations of

percentage all find convenient expression as formulas or equations. Here great care must be exercised that not the empty symbol but the content should ever be present in the pupil's mind. Frequent exercises in interpreting the formulas and giving complete verbal statements for them will tend to counteract this. Again the pupil must always realize that an equation is merely the symbolic writing of a sentence, a proposition in the logical syllogism of the argument.

The two likely errors in the introduction of geometry and algebra into the grades are, of course, on the one hand, a namby-pamby wasting of time, and on the other hand, an attempt to force the too immature minds to mental processes that are beyond them. To carry out this double program should not require more time than is now given to arithmetic in the primary schools. That the present results are lamentably incommensurate with the exertion is commonly admitted, and time is far too precious to waste. Deliberateness, however, not feverish haste and overcrowding, will accomplish most in the least time.

It has been the fortune of the writer to observe the results of two applications of curricula similar to that just described, both of which had passed beyond the stage of experiment into that of established success. In the German Gymnasium arithmetic (both decimal and literal) is taught simultaneously with geometry throughout the grades corresponding to those of our grammar and high schools, and about one year is gained over the best schools of our central states. For a very interesting and discriminating account of the Prussian schools with special reference to the work in mathematics, the reader is referred to Professor Young's little book.

Again in La Porte, Ind., under the superintendency of Dr. W. N. Hailmann, geometry and arithmetic were to be found throughout the first eight grades, geometry and algebra throughout the remaining four. The pupils came to the ninth (or first high school) grade thoroughly familiar with those properties of geometric forms open to observation and excellently prepared to take up demonstrational work, which was the more easily comprehended that it dealt with familiar material.

The abridgement by one year of the school course from the beginning up to the attainment of the baccalaureate is in the air. Can it be effected without sacrificing any valuable results now accomplished, say by wise revision of the curriculum and increased efficiency of methods of instruction? This is a question which, in view of the prominence of mathematics in the course of study, must vitally concern the teachers of mathematics. May not its answer involve some consideration of the changes suggested in this paper?

PHYSICS SECTION

THE USE OF MODELS IN SECONDARY INSTRUCTION IN PHYSICS.

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This topic is not quite in line with the usual,—and I think we would all say,—the best work of this section of the Club. It is offered as a suggestion of an occasional day upon some limited portion of our work, either of material or instruction. I have at present in mind two subjects to which my attention has been strongly called of late:—the relation of the mathematical to the physical instruction in the high school, and an exhibition of models which have been found useful in teaching physics

The subject of models is a large subject and shares in the fundamental difficulties of definition and classification common to all forms of apparatus. For this reason I shall entirely omit definition and attempt only a rough classification of models used in instruction.

CLASSES EXCLUDED FROM CONSIDERATION.

In the natural history sciences a model may mean a representation, often on an enlarged scale, of the whole or some part of some plant or animal. Large cabinets of such models in glass, wax, or other material, may be had. These are not for us.

Collections of models of machinery used in some technological process are often seen:—as, models of a spinning jenny, of a sugar mill, of an ore crusher, etc. Moderately useful as loan collections they are in general hardly worthy of purchase.

The term model is often applied to a simplified form of some complicated research apparatus; as, "Maxwell's Color-Box, Small Model", etc. May be important or not.

MODELS OF INFERIOR UTILITY.

A so-called diagrammatic model is likely to be inferior, other things being equal, to a working model. Such a model attempts to show by parts moving in one plane the action of a mechanism of three diamensions; or, if in three dimensions, it is not "practical", as the theatrical people say; or, it may represent to the eye and touch concealed or invisible parts. A representation in one plane of a section of a lifting pump, of a steam boiler,

of a Bramah press; or, in three planes, of a ray of common light, or, of the parts of an induction coil, are examples of this class. Reusch's apparatus for refraction; Pfaundler's of the course of a ray of light through compensating prisms; or Neu's for the course of a ray through a lens, in all of which the so-called rays of light are represented by wooden rods, furnish examples of this class of models. While these diagrammatic models are in general inferior in value, some of them are of high value, as, for instance, a representation in one plane of a steam cylinder with valve action and related parts. So this classification is not of itself sufficient.

A model of a complicated piece on so small a scale as to be a mere toy can have little value in class instruction.

Models showing mere theory one can in general well do without. The inventor finds enormous interest in making them, but his single example may well suffice. Models showing the nature of inertia, the interaction betwen the molecules of common matter and electricity, the nature of geyser action, of Saturn's rings, furnish examples of this class.

Models illustrating some fact or principle which needs no illustration are quite too common. For example, the rather common orrery or planetarium. I quite agree with Poggendorff that this piece is not only useless but actually harmful. The solar system certainly challenges imitation as well as admiration, and I do not wonder that attempts to represent these complicated motions and relations are often made, but why anybody should buy them is the mystery.

The paper was illustrated by models of a marine engine, of a vernier reading to hundredths, a vernier reading to thousandths, and one showing the locus of a connecting rod.

THE ELECTRON THEORY.

PROFESSOR K. E. GUTHE, UNIVERSITY OF MICHIGAN.

The electron theory which has lately attracted so much attention among scientists may be called the third stage of the development of our theories concerning phenomena connected with electro-magnetic action.

At the beginning of the second half of the nineteenth century *Wilhelm Weber* explained the electromagnetic phenomena known at that time, perfectly satisfactorily, by assuming the existence of two different kinds of electrical fluids, *i. e.*, positive and negative electricity. Electricity could be divided into small particles, atoms of electricity Weber calls them, which act upon one another through space, these actions being transmitted with infinite velocity. The idea of the electrical atom, however, did not at that time lead to attempts to measure its size. Many of our definitions and modes of speaking of electrical phenomena date back to Weber's theory.

It was *Faraday's* master mind which pointed out the short-comings of this theory and emphasized the great role which the medium plays in all electrical phenomena. Then *Maxwell* in his great treatise gave the mathematical basis for the electromagnetic theory of light, and *Hertz* by his famous researches proved that electromagnetic action is not an action at a distance but transmitted by the ether. The possibility of treating the phenomena of light and those of electromagnetic waves from the same point of view, led physicists to abandon Weber's theory and look to the ether and the lines of force, *i. e.*, the stresses produced in the ether, for the solution of all future problems in electromagnetism. According to Maxwell's theory there are no atoms of electricity. We have a continuous ether with certain electrical and magnetic properties and these properties may be modified by the presence of matter.

Now the third period in the development of the electrical theory which may be characterized by the name of the electron theory, means a return, at least to a certain extent, to the ideas of the first, or better, a combination of the two, *i. e.*, we have to allow a right of existence as well to the atoms of electricity as to the continuous ether with its electrical and magnetic stress properties.

In fact the "electric charge" has always been a more or less definite something, which has never allowed itself to be pushed aside entirely in an important branch of electricity, namely, in electrolysis. All attempts to explain electrolytic action on the basis of ether stress have found hardly any adherents among the physicists and we are accustomed to say that in electrolytes certain small particles of matter are charged with a definite amount of either positive or negative electricity, a combination which we call an "ion." When a current goes through a cell, the electric charge is given off at the electrode. It is apparent that, at least during the short time of transference, we think of the charge as having a separate existence. The smallest quantity of electricity found in electrolysis is then that amount which is carried by a monovalent ion—How large is it? We know that one gramequivalent of an ion, say 1 gram of H, carries very nearly 96600 coulombs. The ratio of the charge in electromagnetic units to the mass of one ion of hydrogen is ten apparently 9660 or nearly 1×10^4. The number of gas molecules in 1 cm^3 at 0° and 760 mm/cm^2 pressure of mercury is about 4×10^{19}. As an example take hydrogen. Each molecule is made up of 2 atoms; we nave therefore in each cubic centimeter about 8×10^{19} atoms. One grammolecule occupies 22350 cm^3 *i. e.*, there are 178800×10^{19} atoms in 2 grs. of H. These carry 2×96600 coulombs, so each ion has a charge

$$\text{of } \frac{193200}{178800 \times 10^{19}} = 1.1 \times 10^{-19} \text{ coul.} = 1.1 \times 10^{-20} \text{ electromagnetic units.}$$

Since an electromagnetic unit of quantity of electricity is 3×10^{10} larger than the corresponding electrostatic unit, *we obtain from the consideration of electrolytic phenomena for the electrostatic charge of a monavalent ion about* as 3.3×10^{-10} units.

Even in the electromagnetic theory of light where the wonderful success of Maxwell's theory seemed at first to leave no room for separate electrical charges, they began slowly to gain more and more ground. It was soon found that certain phenomena of light, e. g., radiation from incandescent vapors or the absorption of light by certain substances and especially the dispersion of light, demanded a definite structure of bodies. *Maxwell, von Helmholtz* and others assumed that the material particles emitting light of definite wave length possess one or more distinct periods of vibration and will on the other hand act like resonators for these vibration frequencies and therefore absorb their energy. Thus the material particles whose atoms carry positive and negative charges, were supposed to create by their vibrations electromagnetic disturbances of the ether.

H. A. Lorentz of the University of Leyden assumed as early as 1880 that not the material atoms of the substance but only an electric charge connected with it and having a vibration period of its own produces the electromagnetic phenomena of light. Starting from this hypothesis he was able to explain by means of a formidable structure of mathematical formulæ the apparent exceptions to Maxwell's theory. But Lorentz's greatest success was to come 16 years later; his theory, similarly to Maxwell's, had to wait for an experimental proof.

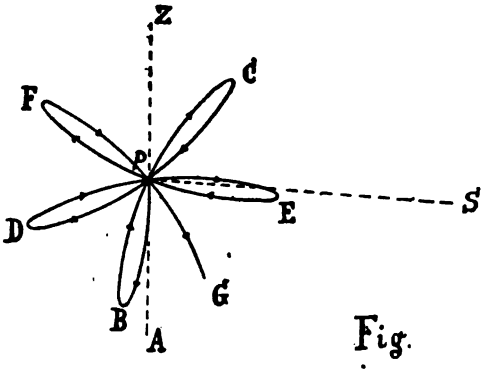


Fig.

Let us see whether his theory could predict effects of magnetic and electrostatic fields on light rays, which had not been observed before and which by being found would of course strengthen it. We suppose with Lorentz that the small electrical charges which we shall from now on call "electrons," a name first used by *Stoney,* swing rapidly about a point of rest and by their influence upon the ether produce light radiation. Let such an electron, which we consider as a negative charge, after it has left its position of rest be subjected to an elastic force pulling it back. It will swing then in a simple harmonic motion in a straight line and produce light of a definite wave length. But now suppose we bring this swinging electron into a strong magnetic field. A moving electrical charge will be acted upon as a flexible current would, *i. e.,* if we suppose the magnetic lines of force go from the front vertically through the plane of the paper and a negative electrical charge to start from the point, *P* (see figure —), vertically down parallel to

the plane of the paper, it would, instead of going to *A*, be deflected to the left so as to describe the path *PB*. After having reached its maximum elongation at *B*, it will return to its position but on a path concave towards the right and thus describe a loop. Constructing the path it takes during several vibrations, it will reach the points *C, D, E,* etc., the width of the loop depending on the strength of the magnetic field. We are accustomed to consider a motion in a loop as this as the resultant of two separate motions, say one in a vertical direction alone *A Z* and one at right angles to it, along *P S*.

The question arises: What kind of light will be emitted from an electron moving in the manner described? Let us take the direction *PS* as the direction of propagation of the light. Light vibrations are always at right angles to its direction of propagation, *i. e.,* we must suppose that only the component at right angles to *PS* can be propagated in this direction as light, but not the component parallel to it.

It is apparent that the vibrations parallel to *A Z* will alternately increase and decrease in amplitude. In sound we are perfectly familiar with such phenomena: we say we have "beats," whose effect is the same as if two vibrations with somewhat different periods were present. Our eye is not sensitive enough to see these extremely rapid light beats, but in using a spectroscope we should expect two lines of distinct wave length corresponding to these beats. Moreover according to the theory of light ether vibrations at right angles to the plane of the paper would also be propogated as light rays in the direction *PS,* but on these the magnetic field has no influence, *i. e.,* their amplitude remains constant. We shall therefore see in the spectroscope also a line between the other two, this line corresponding to the natural wave length of the light emitted by the body. The effect of bringing a body emitting under ordinary circumstances light of a certain wave length into a strong magnetic field and looking at it through a spectroscope in a direction at right angles to the magnetic lines of force, is therefore, that we see instead of the usual one bright line now a triplet of bright lines. This phenomena which Lorentz's theory demanded, has been found experimentally by *Zeeman* in 1896, it is the famous "Zeeman effect." Various bright lines emitted by incandescent vapours have been studied under these conditions and Zeeman has calculated from the mathematical theory the ratio e/m of the electrical charge to the mass of such a vibrating electron. For each of the two D lines he found it to be 1.6×10^7 electromagnetic units per gram, for the Cadmium line 2.4×10^7. Comparing this result with what we found above for the same ratio in electroytic phenomena, namely about 1×10^4, *we obtain the very surprising result that it is in this case more than a thousand times larger.*

Thus Zeeman by his famous discovery strengthened considerably the electron theory introduced by Lorentz into the electromagnetic theory of light.

While the new electron theory was originated in connection with Maxwell's theory, its importance was seen more clearly when purely electrical phenomena also demanded the existence of electrons. I refer to the interesting results obtained by the study of the "cathode rays." These rays are emitted from the negative electrode of a Crooke's tube, when worked with an induction coil; they travel in straight lines, can be deflected by a strong

magnet and produce at an object which they meet in their path the same effect which small particles of matter would if moving with great velocity. *Crooke's* hypothesis that these rays were charged gas molecules repelled from the electrode, had to be given up as soon as quantitative measurements of the ratio between the electrical quantity transferred and the corresponding amount of matter were made. Closely connected with these measurements are the names of *Wiechert, J. J. Thomson, Kaufmann, Lenard* and others. Their investigations have led to the result that *in cathode rays this ratio* e/m *equals about* 1.85×10^7, *i. e., the same number as the one found for electrons emitting light.*

Several different methods may be employed to calculate the ratio, the simplest one being the following:

If we have a strong magnetic field of strength H at right angles to the direction of the moving electrons, the force with which the charge is deflected from its rectilinear path equals $H\ e\ v$, where e is the charge on one electron and v its velocity. Acting against this force we have the centrifugal force $= mv^2/r$ and a steady deflection is obtained when the two are equal to each other, *i. e.*, $H\ e\ v = mv^2/r$, $r = mv/eH$ where m is the mass of the particle. The electron describes therefore the arc of a circle whose radius is $r = mv/eH$. Now H and r may be measured and thus mv/e found. To eliminate v let an electrostatic and a magnetic field at right angles to each other act at the same time upon the moving electron and adjust the strength of these fields so as to have one just balance the effect of the other. The force on an electric charge e in an electrostatic field of strength F is Fe, therefore under the given conditions $Fe = evH$ or $v = F/H$. Substituting this value of v in the above equation we obtain $v = m/e\ F/H^2$, or $e/m = F/v\ H^2$. Now we have on the right hand side only quantities which we can measure. By this or similar methods a great many observers have found the velocity of the cathode rays to be from 0.3 to 0.9×10^{10} cm/sec or about 1/10 to 1/3 that of light, while e/m by the most accurate methods was found to be about 1.85×10^7 electromagnetic units. The most important result however is that *for different gases this ratio does not change, i. e.*, "the electrons seem to form an invariable constituent of the atoms or molecules of all gases and presumably of all liquids and solids" (J. J. Thomson). To carry a given charge of electricity through an electrolyte requires therefore a mass at least 1000 times greater than if the carriers are cathode rays.

The question whether there are positive electrons has also been investigated. If in a Crooke's tube the negative electrode is perforated, the positively charged atoms pass through these holes and form the so-called "canal-rays." *W. Wien* has found that for these positively charged particles the ratio of the charge to the mass is the same or even smaller than for electrolytes. In other words the canal-rays are produced by "ions" and not by "electrons," the latter being characterized by the large ratio e/m. Real electrons with a positive charge have not been found as yet.

We cannot leave this part of the subject without mentioning other occurrences of electrons. A part of the "Becquerel rays" are of the same nature as cathode rays. These rays emanate as Becquerel first discovered from

certain Uranium salts and they led to the discovery of the new elements Radium (and Polonium?) by Mr. and Mme. *Curie*. These elements send out among others very strong invisible rays which are not stopped even by thin sheets of metal and at first were thought to be similar to "Röntgen rays."

But as soon as *Dorn* and *Becquerel* had shown them to be deflected by a strong magnetic field it became apparent that they belong to the same class as cathode rays. Measurements similar to those described above gave for the velocity of these very penetrating Becquerel rays from 2 to 2.8×10^{10} cm/sec, *i. e.*, almost as large as the velocity of light, while e/m did not differ much from the ratio found for cathode rays. But in this case, and this is of the greatest importance for the development of the electron theory, *Kaufmann has found that the ratio e/m depends for these electrons travelling with such enormous velocity upon their speed,* being the larger the greater the velocity. Another part of the Becquerel rays, namely, those which are easily absorbed and called the -rays, have lately been investigated by *Rutherford* and *Becquerel,* who found their velocity $= 0.2 \times 10^{10}$ cm/sec and $e/m = 6 \times 10^{3}$. They are therefore very similar to the canal rays and probably positively charged atoms.

Electrons appear however to be much more frequent than in the isolated cases which we have thus far considered. In fact conduction of electricity in gases seems always to be due to the presence of electrons. They may be produced in a number of ways. If you illuminate a charged conductor by Röentgen rays, Becquerel rays, or ultraviolet light, it will lose its charge. Bodies heated to bright red heat or still higher send out electrons. But the most efficient means is through a violent electrical impulse as in the case of cathode rays.

The result of all these experiments is that electrons, or negatively charged particles exist, in which the ratio of the charge to the mass is more than 1000 times larger than it is for a hydrogen ion. A question of greatest importance is: Is the mass of one electron that of an atom, carrying a very much larger amount of electricity than it can in electrolytic action, or is the charge, connected with each particle, the same as that connected with a monovalent ion and is its mass less than the one-thousandth part of that of an hydrogen atom? *J. J. Thomson* has solved this question in a most ingenious way. If a moist ionized, or better, electronized gas is expanded adiabatically the water condenses in drops around the ions as nuclei. If the proper proportion between the water and the ions is chosen the number of water drops equals the number of ions. As *Stokes* has shown, the radius of each drop of water can be measured by the velocity with which a fog formed by the drops sinks down. From the radius and the total amount of water present the number of drops can be calculated. J. J. Thomson found by this method for the charge of each drop, *i. e.*, each electron 1.14×10^{-20} electromagnetic or 3.4×10^{-10} electrostatic units or nearly the same value for each charge as we found for each ion. This charge may therefore be called the smallest quantity of electricity existing, or an atom of electricity; and it may be of interest to know that *M. Planck* has found practically the same number, 4.69×10^{-10} electrostatic units from his theoretical studies on the distribution of energy between

ether and matter. On the other hand it follows that the mass of an electron is smaller than the one-thousandth part of a hydrogen atom. According to J. J. Thomson the so-called ionisation of a gas consists then in a separation of the negatively charged corpuscle, as he calls it, from the remaining part of the atom or molecule, which is left charged positively; in other words positive electrification consists in the absence of these corpuscles from ordinary atoms.

But here the theory cannot stop. A separate mass so much smaller than what we have always supposed to be the smallest and indivisible part of matter, is something so new, that it is natural physicists should have tried to explain away entirely this last trace of matter left in the electrons. And surely in considering the problem before us we must all acknowledge that at least a part of this mass can be only apparent. Let use follow *O. Lodge* in his clear statement of the case, given only a few months ago before the institution of electrical engineers in England.

A moving charged particle is equivalent to an electric current whose strength depends of course upon the velocity of the particle. A magnetic field is set up around an electric current. If the motion starts in *i. e.,* while the charge receives an acceleration, the strength of the magnetic field increases and by electromagnetic induction a counter E. M. F. is produced, which according to Lenz's law acts so as to oppose the action producing the magnetic field, *i. e.,* we have here something which seems to hold the particle back. If the motion is suddenly stopped, induction would tend to continue the motion. We have therefore here something very similar to the inertia of a moving material body opposing mechanical acceleration. But in our case the phenomenon is due entirely to the electromagnetic induction produced by the electrical charge alone, not by mass. It is clear therefore that whatever inertia a moving material body would have due to its amount of matter, it will surely have a larger inertia and therefore a larger apparent mass in virtue of being charged with electricity. *Heaviside* has calculated the energy of a moving charge to be, $Energy = \mu\, e^2u^2/3r$, where μ is the magnetic permeability of the medium, e the electrostatic charge, u its velocity and r the radius of the sphere on which the charge is supposed to be distributed. This kinetic energy measured in mechanical units would be represented by $\frac{1}{2}\, m\, u^2$ where m is the apparent mass, or $\frac{1}{2}\, m\, u^2 = \mu\, e^2u^2/3r$ and $m = \frac{2}{3}\, \mu\, e^2/r$. We may change the expression slightly. The potential of a sphere of radius r in a medium whose dielectric constant is K, is $V = e/rK$, so the apparent mass is $m = \frac{2}{3}\, \mu\, K.e\, e/rK = \frac{2}{3}\, \mu\, K.\, e \times V$. Now the ratio of the electromagnetic unit of quantity of electricity equals 3×10^{10} com. per sec. (*i. e.,* velocity of light) and also equals $\sqrt{\mu K}$. So by denoting the velocity of light by v, we have $m = 2/3v^2\, eV$.

The potential energy of the charge e measured in electrostatic units is $\frac{1}{2}\, e\, V$. But if we have instead of the charge a material particle of mass m moving with the speed of light, its kinetic energy would be $\frac{1}{2}\, mv^2 = \frac{1}{3}\, eV = \frac{2}{3}\, (\frac{1}{2}\, e\, V)$. If a material body having a mass equal to the apparent mass of the moving charge were travelling with the velocity of light, its kinetic energy would be two-thirds the potential energy of the electrical charge when standing still.

Let a sphere be charged to one volt by a quantity of one coulomb. The electrostatic unit of E.M.F. is 3×10^{10} larger than the corresponding electromagnetic unit, but the ratio is just reversed for the units of quantity of electricity, therefore the electrostatic energy corresponding to eV is the same as the electromagnetic energy of one volt-coulomb, namely, 10^7 ergs. Its apparent mass would be $\frac{2}{3}\ 10^7/9 \times 10^{20} = 2/27 \times 10^{-13}$ gr. $= 10^{-11}$ mg., a very small mass indeed. As we saw above, the charge on one ion is 10^{-10} electrostatic units. The radius of an atom is about 10^{-8} cm, so the electrostatic potential of an ion is 0.01 electrostatic units $= 0.01 \times 3 \times 10^{10} = 3 \times 10^8$ electromagnetic units $= 3$ volts. Its apparent mass due to the charge which we may assume as $\frac{1}{3} \times 10^{-19}$ coulombs, is then $m = 10^{-14}$. $10^{-19} = 10^{-33}$ grams. Comparison with the mass of a hydrogen atom, 10^{-25} grams, shows it is negligible.

In the case of an electron there is however no necessity to assume the radius to be as large as that of an atom, on the contrary it is probable that it is very much smaller than that. Therefore supposing it to be 10^{-13} cm instead of 10^{-8} cm, its potential would be 1000 electrostatic units $=$ 300000 volts, and its apparent mass $m' = 10^{-28}$ grams or about one one-thousandth of that of a hydrogen atom.

The apparent mass of an electron, found experimentally would follow directly from the assumption that the charge is distributed over a sphere of a very small radius and under these conditions, the supposition that the charge is connected to a material particle, is entirely unnecessary. This way of looking at the subject has been strengthened by mathematical deductions and experiments of very recent date. Some time ago it was shown by *Heaviside* that for a charge moving with a velocity smaller than that of light, *e. g.*, the electrons of the cathode rays, its apparent mass will always bear the same ratio to the charge, independent of the velocity, but that the mass would appear larger, if the velocity increases and approximates that of light. Now, as I told you before, the Becquerel rays travel much faster than ordinary cathode rays and reach ¾ of the speed of light. So while the cathode rays show always the same ratio e/m we should expect an increase of the apparent mass with the velocity for the Becquerel rays, and this has actually been found by *Kaufmann*.

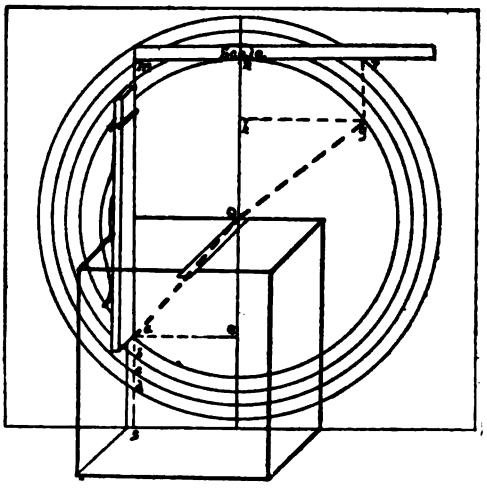
Besides theoretical calculations published a month or two ago by *Abraham*, which were based on the supposition that the so-called mass of the electrons is due only to the inertia effect produced by a rapidly moving electric charge without any mass, led to equations which when compared with Kaufmann's results showed a complete agreement between theory and experiment.

The temptation to extend now these ideas still further is very great indeed. So we must expect in the near future attempts to explain matter as consisting simply of conglomerates of moving electrons, and this would lead us finally to assume as the framework of our universe a continuous ether and imbedded in it the electrons which by the particular manner of combination and motion give rise to the effects we now attribute to matter. The first steps in this direction have been made. Let us hope it is in the right direction and that the electron theory of matter will not in the end prove to be a scientific mirage, which with all our efforts we will never be able to reach.

APPARATUS FOR THE DETERMINATION OF THE INDEX OF REFRACTION OF WATER.

A. O. WILKINSON, DETROIT.

Referring to the accompanying diagram the construction and the working of the apparatus will be easily understood. The apparatus consists of a pine board about 12x18 inches clamped in a vertical position, having several concentric circles drawn upon it. A vertical line is drawn through the center of the circles; to the left of the center, about half of the radius, a line is drawn parallel to the vertical. In front of this board is a rectangular jar whose top is even with the center of the circles. A wooden rod is arranged



to slide inside the jar so that its right hand edge coincides with the line *m s*. A thin metal strip is placed on the jar so that its edge coincides with the center of the circle. The jar is filled with water as full as can be without its couching the metal strip. The lower end of the sliding rod is made to coincide with the intersection of a circle and the line *m s*. By sighting a pin is placed in the same circle so that the end of the rod, the edge of the metal strip, and the pin appear to be in a straight line. The line of the angle of incidence *a e* and of the angle of refraction *h g* can be read on the scale *m r* and the index obtained by dividing the latter by the former. Other trials can be made by using the other circles.

THE INDEX OF THE REFRACTION OF GLASS.

H. N. CHUTE, ANN ARBOR.

For the past sixteen years I have been using what might be termed, by way of distinction, the pin method, of determining the index of refraction of glass. Those who have not tried this method are likely to class it as

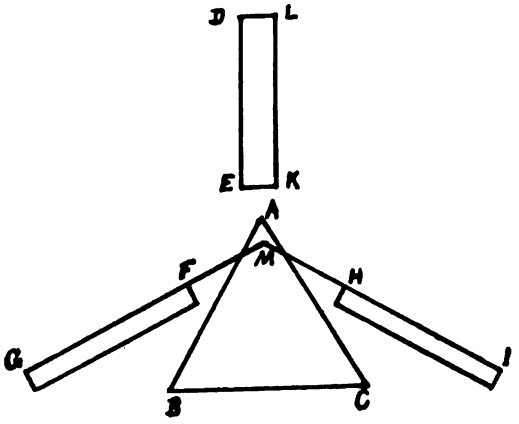


Fig. 1.

crude and not calculated to yield even an approximation. The purpose of this paper is to call attention to the simplicity of the method and to show by an example the degree of accuracy possible. Of late I have been substituting rulers for pins with good effect.

The apparatus needed is a glass prism, three short narrow rulers, a protractor, and a small square board. A sheet of white paper is fastened to the board with thumb tacks.

The first step in the problem is to measure the refracting angle of the prism. The prism, Fig. 1, is placed on end near the center of the board and a ruler, D K, placed at the angle, A, to be measured as shown in the figure. Rotate the board till the light from the window brightly illuminates the edge, D E. Then, place a second straight edge so that its edge, G F, is exactly in line with the reflection of D E seen in the face, A B, of the prism. With a finely pointed pencil draw a line along the edge G F. Now rotate the board to a position in which K L is illuminated and place the ruler H I in line with the reflection of L K in the face A C. Draw the line, H I. Remove the prism and continue the lines G F and H I till they intersect at M. With the protractor measure the angle G M I. Half of this angle will be the value of the angle A in accordance with the principle that the displacement of the reflected ray is twice that through which the mirror surface turns,

since D E may be considered as a ray of light incident on a mirror surface A B which by rotating through an angle A forms the other face, A C, of the prism. The angle G M I thus becomes the angle through which the reflected ray is displaced.

To measure the angle of deviation, mount the prism as before, and place one of the rulers with its edge making an acute angle with the face, A B, of the prism. Fig. 2. Turn the board till the light strikes the edge of the ruler, and then place the second ruler, F G, so that by sighting along F G it seems to be in line with the edge, D E, seen through the prism. The edge,

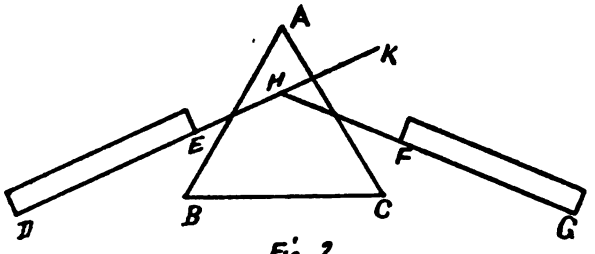


Fig. 2.

D E, of the ruler seen through the prism will be colored with the spectrum tints. Now turn the prism till the edges of the rulers seem to make equal angles with these faces. This may put the rulers a little out of alignment and adjustment of them will be necessary. Draw the lines, D E and F G. Remove the prism and prolong the line G F cutting D E produced at H. With a protractor measure the angle K H G. This will be the angle of deviation.

It is shown in geometrical optics that $\mu = \frac{\sin \frac{1}{2} (a + d)}{\sin \frac{1}{2} a}$ in which

a is the refracting angle and *d* is the angle of deviation. By substituting the value obtained for these angles in this formula, the index of refraction is obtained.

To test the accuracy of the method I applied it to the prism on one of Browning's spectroscopes. The refracting angle of this prism as given by using the instrument to which it belongs is 59° 48′ 20″. Using rulers I obtained the following values:—

119.75
119.50
119.75
119.50
119.50

119.69 ÷ 2= 59° 48′, showing a difference of only 20″.

The angle of deviation of the F-line as given by the spectroscope is 51° 38′. Using rulers I obtained the following values:—

51.75
51.50
51.75
51.50
51.00
51.25

51.46 = 51° 27′.6, showing a difference of 10′.4, which is in part due to the alignment not being made exactly on the E-line of the spectrum.

Using the spectrometer values the index = 1.657.

Using the method of alignment values the index = 1.656.

The method commends itself for the following reasons:—

1st. The inexpensiveness of the apparatus.

2nd. No dark room is required.

3rd. It is based on the same principles as the spectrometer method, the rulers taking the place of the telescope and collimator.

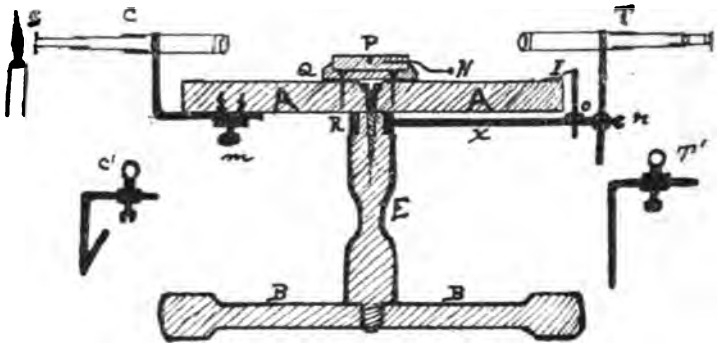
4th. It lends itself to quite a high degree of accuracy.

A SIMPLE SPECTROMETER.

BY CHAS. H. SLATER, PONTIAC, MICH.

A Spectrometer is ordinarily too expensive a piece of apparatus for most high school laboratories to possess. One that answers all the purposes very well may be easily constructed and at a very moderate cost. The base (B B) of the one herein described was the support for an old planetarium long since laid on the shelf. In the absence of one of a similar nature, a base may be easily devised which should be broad and of well seasoned hard wood, the upright (E) being about 12 inches high and 2½ inches in diameter. The top of the upright is turned round 1½ inches in diameter and ½ inch wide. On this shoulder is a closely fitting iron ring (R) into which is screwed a rod (X), the support for the reading telescope (T). The circular disk (A) is thoroughly seasoned walnut 1 inch thick and 13 inches in diameter. A 3-inch screw holds it firmly to the upright (E). A circular scale reading to the fourth of a degree is glued to the rim of disk (A). A prism stand (P) is placed at the center of the disk (A). It consists of a circular plate (P) which rests in a closely fitting piece (Q). An object on the plate (P) can be rotated to any position by the handle (H). The reading telescope (T) has vertical and lateral adjustment so that it

may be easily centered. A small brass pointer (I) is mounted in front of the telescope; it serves the double purpose of a reading index and a partial support for the telescope rod (X). The collimator (c) is mounted on a rod bent twice at right angles (c′) and clamped at (M) in such a position that parallel rays from the right (s) will pass across the center of plate (P).



A collimator is obtained by altering a second reading telescope as follows: The lenses in the eye piece are removed and a small metal slit is placed between the aperture and the small shutter in the eye piece. The focal length of the objective lens being found, the tube is then adjusted to that length, clamped in position at (M), centered, and the spectrometer is ready for use.

As to expense: A blacksmith will do the necessary metal work for $1.00 and good telescopes can be gotten for $2.00 each, but they will serve many other uses, as in timing the pendulum, reading the galvanometer, and for showing the construction of a telescope. Every laboratory should have two at least. The circular scale costs 35 cents. Thus any laboratory that possesses the telescopes may obtain a satisfactory spectrometer at an actual cost of less than $1.50. The usual cost of high school spectrometers is from $20.00 to $40.00.

WHAT TO PUT IN A NOTE-BOOK.

E. L. KEELER, CENTRAL NORMAL, MT. PLEASANT.

This is a very important subject and one upon which all teachers of Physics do not think alike. Some think one thing and some another.

Let me ask—what does the note-book do for the student, or rather what should it do? I believe it trains him to observe carefully and accurately; to think sharply and logically, to express with clearness and precision and to formulate exact statements of his results. It fastens the lessons taught by an

experiment firmly in the student's mind and lastly it furnishes a record for future reference or study.

I believe you will agree with me that these are some of the main objects of a note-book and if so it is a very important piece of apparatus for the Physical laboratory.

It has been my observation and experience that the great trouble with the young people of today is the inability to make a good, clear, accurate statement or record of anything. Think of some of the examination papers you received last week, or some of the letters you are receiving daily and I am quite sure they will bear out my statement.

It is just as essential that the pupil be able to tell in a straightforward, accurate and vigorous way what he has done and how he did it as it is for him to do it at all. The note-book should help the student in getting a clear conception of all that the experiment is intended to convey.

The note-book is as important as the experiment itself, but the manner in which some note-books are kept is worse than nothing from the standpoint of Physics and English. Some are lumbered up with useless material and very important data left out. This is one of the serious troubles, if not the most serious one, with which every teacher has to contend. The student must learn to discriminate between important and unimportant data and detail, and the rightly kept note-book will teach this discrimination.

The first thing to be placed in the note-book is the date of the experiment. This should be followed by the number of the experiment, or a brief statement of it. Following this should be the purpose of the experiment which should be stated in simple, clear language, giving the object of the problem or experiment.

If the apparatus is not described in the manual, I would require the students to do it briefly. This will assist them in understanding the experiment. Often a little more than an illusion to the drawing will be sufficient.

This leads me to the question—what kind of a drawing shall be placed in the note-book? Must it be a work of art? Should it be a perspective drawing or sketch? In short, should it be a picture? Most emphatically *no*. Such a drawing has no place in the note-book. The drawing should be limited to such diagrams as are necessary to explain the work. A mere outline drawing accurately done is all that should be required.

When should this drawing be done and when should the notes be recorded in the note-book? To this question there is but one answer and that is, as soon as they are taken. I am opposed to taking rough notes and then recopying them. This is done in too many high schools. The working of the experiment and making a record of the work should not be separated. These two processes should be made one and I do not consider the experiment is complete until a record of it is made.

There is but one time and one place to make this record and that is in the laboratory and at the time the experiment is performed. I feel that this record must be made before the interest is lost, or the details forgotten. If the record is made in this way, I am sure it is not drudgery. The students enjoy it rather than dislike it because they are never behind with their notes.

Require the students to keep their note-books in the laboratory. They are necessary pieces of apparatus for the laboratory. Make the first notes final. Limit everything to the experiment and allow nothing in the note-book that does not pertain to the experiment. Care must be taken that every measuremet and determination is recorded in such a way that the meaning of the data will be perfectly clear and self explanatory, and that the statements conform to the results found in the laboratory.

The form of the record is a very important question. It often determines the interest taken in it by the pupils. The record should be simple and to the point and this is seldom so unless the teacher gives them a model. A point is reached and often times missed when the student endeavors to state it. I have seen students write a dozen lines to say that the diameter of a wire is five milimeters.

I am in favor of representing the data graphically. This method will show the eye the relation between two quantities which are connected, so that any change in the value of one produces a change in the other. For example:—The relation of volume and weight of different masses of the same substance. In introducing the student to the subject of plotting it is desirable that the relation to be represented should be as simple as possible and therefore I think a straight line should be the first one plotted and this implies that one quantity is proportional to the other while a curve implies that the law connecting the two is more complex. It will be seen on account of errors of observation the points will not all lie in a straight line, or a curve, but that they may be a little to the one side or the other. This will point out where mistakes have been made in observation and show where approximate values would be. Such work as plotting curves can scarcely be overestimated and I believe in general we do too little of it.

The argument and operation should contain the entire mathematical calculation by which the results are obtained and the analysis of the steps taken to secure these results. In this paragraph, I would have the theory of the experiment given and a discussion of the error of the result.

Under operation, 1st—A very brief, concise statement of what was done. 2nd—A careful arrangement of the data. 3rd—Interpretation of the data from which arises the conclusion. When the law is proved the students should see the proof of the law in his figures. Many times I have observed students state conclusions drawn from their own knowledge from the text-book and not from their work in the laboratory, or to state false conclusions. These I have found to be quite common in *qualitative* experiments. It is distressing to a teacher to see a pupil make a neat record and then derive a wrong conclusion, or state something that has no connection to the problem.

Let me say in conclusion, First—that the written work in the note-book, when properly done, is splendid training in English besides fixing the experiment better in the students' mind and that it trains the student to express himself, accurately, logically and briefly. Second—that there is one time and one place for the note-book work and that is in the laboratory where the experiment is being performed or shortly after. Third—that the

drawing should be an out-line drawing and never a picture. Fourth—that much work should be done in representing the data graphically. Fifth, and last—that the argument and operation should contain the entire mathematical calculation which should lead to the conclusion and that the student should see the proof of the law or theory of the experiment in his own work.

HOW TO DISCUSS ERRORS WITH PUPILS.

C. H. SLATER, PONTIAC.

The following question and answer is found in an article in School Science some months ago: "What are the characteristics of the training given by laboratory courses? In the first place, the critical faculty is directly stimulated, the observing powers are in constant exercise, and a wholesome self reliance is cultivated." The first reply to this question brings directly before us the importance of a due consideration of the treatment of errors. The pupil very soon finds that most statements in the book are only approximately true under the conditions of his experiment. He observes the effects of varying the conditions of the experiment. Soon, he discovers that greater care and better apparatus lessen the variations from correct values and as a result he gains confidence in his own work, understands his results better, and determines for himself the degree of dependence to be attached to them.

It will therefore be the purpose of this paper to refer briefly to a few of the points to be considered in discussing "Errors" with one's pupils. In a general way, the subject should be outlined and explained by the instructor at the time their first laboratory directions are given previous to beginning that work. As it proceeds, individual attention can be called to errors as specific cases arise. After a half dozen experiments are completed a part of a period at least could profitably be given up to a further discussion of causes, remedies, and kinds of errors, and the benefit to be derived from a consideration of them. The note-book discussion of each experiment should give a good account of such errors as may occur and their effect on the results. This first discussion of errors should by all means distinguish clearly between errors and mistakes. The former can not be avoided; the latter should seldom occur. The one offers an opportunity for improvement, the other is failure. Mistakes have their origin largely in lack of preparation, together with careless, hurried, and impatient work. As a result, it often becomes necessary at first to give a pupil lessons in arithmetic or reading and to ask for repetitions of the experiment. He also observes a class-mate working near by who is more successful because of previous preparation and careful, thoughtful work. Thus the poorly prepared pupil sees half his time wasted, sees classmates go ahead of him and the lesson of avoiding *mistakes* is soon learned. I find also the requiring of a good permanent record

lessens the number of mistakes. On the other hand errors must occur, but they may be made small and some nearly eliminated. The pupil's task is to point out where they arise, to show their effect on the result obtained, and to explain any device or method by which they may be avoided. To enable them to do this I find the following classification to be helpful, viz.: General, Instrumental, and Personal Errors. The most common may be called General Errors which include such as result from inexperience, limited time, poor light, approximating fractional parts of scale units, etc. These may be eliminated in a large measure by the method of averages and by varying the conditions as much as possible. The use of checks at every available place aids greatly in detecting errors and mistakes, one other thing that might be mentioned as a general remedy because of its very healthy influence on the work is to require the finding of the per cent of error in all quantitative work. These general sources of error and remedies as the name signifies apply to all experiments, while the other kinds are more special and must be treated as they arise. Instrumental and Personal Errors are for the most part remedied by special devices of method and apparatus. The former will include such errors as result from crude apparatus, friction, parallax, Capillarity, radiation, etc.

Personal Errors are such as depend to some degree on one or more of the senses, as on touch in the adjustment of the micrometer screw and Vernier Calipers, or on hearing and sight as in measuring the length of a resonant column of air, or finding the laws of vibrating strings. It certainly would be interesting to discuss at some length methods and devices for eliminating these instrumental and personal errors, but they are so well pointed out in our manuals that it will not be necessary to take them up in this paper. As to the value of a consideration of errors, little need be said to the pupil. To him there are several obvious reasons. He judges the accuracy of his own work and sees the advantage of this or that method under such and such conditions. His ingenuity is exercised, while at the same time constructive and careful habits are formed in overcoming difficulties that arise which hinder him from obtaining the desired results.

(a) WHEN AND WHERE SHOULD THE NOTE-BOOK BE WRITTEN? (b) CORRECTION OF NOTE-BOOKS.

L. M. PARROTT, SAGINAW.

The topic as assigned involves two thoughts. I cannot *answer* either of them. In the few moments allotted me, however, I will but briefly attempt to present the method I have followed and then throw it open for discussion.

Two days before his laboratory period each pupil is told the number of the experiment he is to work, and is expected to have both himself and notebook prepared when he enters the laboratory, so that he can immediately attack his problem by a straight from the shoulder method. At the begin-

ning of the laboratory period he is handed one of the printed forms indicated below, and all his data is recorded in duplicate, in his book and on this form, exactly as taken. This duplicate is left with the teacher, all the calculations being indicated below the recorded data and as much worked out as time permits. Then, during the coming week, each pupil in the quiet of his own home must write a discussion of his experiment, bringing out its purpose, the principles involved, his observations, manipulations, conclusions, etc., in the very best literary style of which he is capable.

SAGINAW, EAST SIDE, HIGH SCHOOL.

PHYSICAL LABORATORY.

.....190.. Experiment No. .....

APPARATUS: { ..... No..... ; ..... No..... ; ..... No..... ; ..... No..... }

Calculations:

.....

These data sheets enable the teacher to keep in close touch with each student's progress, and a daily record of what has been attained. Each is carefully looked over, the character of the data taken and the indicated calculations outlining to a large degree what the pupil has acquired from the experiment. Once a month the books themselves are put in the teacher's hands and the discussions are carefully read, marked, and points noted for consultation with the pupil.

A METHOD FOR DETERMINING THE DENSITY OF GASES.

F. R. GORTON, YPSILANTI.

That air has weight may be ascertained by the use of an incandescent lamp bulb and a balance that turns easily with 0.1 gram. The bulb is first counterpoised by means of shot or sand. Air is then admitted by inserting a nail in the neck of the bulb and tapping it lightly with a mallet. The end of the tube C shown in the figure is thus broken off and every fragment caught in the bulb. On replacing the bulb upon the balance a gain of nearly 0.2 gram is shown.

In order to ascertain the density of air, it is advisable to remove the brass fixture attached to the bulb and clear away every particle of cement. The bulb is then weighed as accurately as possible. Dry air may be collected in a small gas bag, from which it is admitted into the bulb by a T-tube arranged as shown in the figure. The rod D extends through the tube projecting at the ends. The joint A is made air tight by means of rubber tubing. At B a piece of tubing causes the glass tube to make an air-tight connection with the bulb N. If the inlet pipe is now connected with the gas bag, a tap upon the rod at D will break the bulb at C and admit air from the gas bag. The gain in weight having been found, the volume of air admitted is determined by filling the bulb with water of known density and weighing.

The density of other gases is found by filling the gas bag with the dry gas whose density is required and admitting it in the same manner.

AN EXPERIMENT FOR ILLUSTRATING OSMOTIC PRESSURE.

C. F. ADAMS, DETROIT CENTRAL HIGH SCHOOL.

It is well known that the walls of many plant cells form "semi-permeable" membranes. Such membranes allow diffusion of certain substances through them in one direction while not permitting diffusion in the opposite direction. Dr. Louis Murbach, of our school, first called my attention to the use of the carrot and other similar vegetables for the purpose of illustrating osmosis.

To perform this experiment a hole is bored along the axis of a large, sound carrot, about 10 cm. deep and 2.5 cm. in diameter, a carpenter's bit being used for the purpose. I also peeled the carrot up to its crown, although I suspect that this is unnecessary. The cavity in the carrot is then nearly filled with sugar and water added to it to within a centimeter of the top. To close the cavity a two-hole rubber stopper is used, in one hole of which is inserted a long piece of barometer tubing having a bore of about two millimeters. After the stopper is driven firmly into the carrot the other hole in

the stopper is closed by a glass plug. There should be sufficient water in the carrot to entirely fill the cavity so that the insertion of the glass plug will force the water a centimeter or so up the tube. The carrot and tube are then supported by a clamp so that the carrot stands entirely submerged in a dish of water. If care has been taken to put the apparatus together so that there is no chance for leakage the liquid will immediately begin to rise in the tube.

At my first attempt with this experiment the liquid rose to the top of a tube 130 cm. long in two hours and a half. I filled the same carrot again lengthening the tube to 308 cm. and allowed it to stand during the night. In the morning the current was still upward while a trail of thick syrup on the outside of the tube showed that the sugar solution had run over during the night. I again connected the same carrot by a U tube to a bottle filled with mercury and the mercury was forced up a tube 63 cm. when on my attempting to move the apparatus a leak occurred and put an end to the experiment.

As the osmotic pressure of a saturated solution of sugar is known to be several atmospheres I would suggest that one might in this way force the mercury up to a considerable height. Possibly it would be found advantageous to bind the carrot with cheese-cloth to prevent its bursting, and the stoppers would certainly need to be fastened in place. I hope to hear that someone has taken the matter up and secured interesting results.

GAS GENERATOR.

PRINCIPAL JOHN P. EVERETT, PONTIAC.

When I began teaching physics at Grass Lake I met with a difficulty usually encountered in small places—no gas for laboratory purposes. The matter seemed of sufficient importance to warrant some attention, and the apparatus herein described is the result. For the main ideas embodied in constructing the generator I am indebted to Dr. Chadwick. My work was rather one of adaptation than of invention.

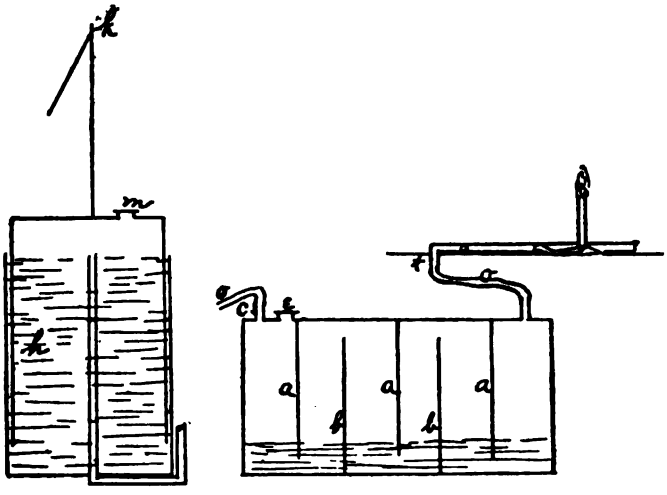
The operation of the generator depends upon the fact that an inflammable gas is generated by pressing air through gasoline. The actual generator consists of a galvanized iron box 12 in. x 10 in. x 7 in., a longitudinal section of which is shown in the accompanying diagram. Let down from the top and soldered to the sides are three partitions (a) which reach within half an inch of the bottom. Two partitions (b) extend from the bottom to within half an inch of the top. Gasoline is introduced by means of an air-tight cap (e). The bottom should be covered from one to two inches. Even distribution is secured by tipping the generator on its side and righting it by turning on its longitudinal axis. If air is forced in at (c) it must pass through gasoline three times and emerges at (d) a highly inflammable gas.

The required air pressure at (c) is afforded by the common arrangement of two cylindrical tanks (h), the lower being filled with water. I used

tanks about three feet in diameter and of a height equal to twice the width of galvanized sheet iron. The upper tank must be weighted. A triple pulley (k) fastened to the ceiling was used in raising the tank. Air is admitted as the tank rises by removing the cap (m).

For conducting the gas from the generator I used a half-inch gas pipe (t) running along the back of a bench. Into this pipe were let ordinary air cocks for attaching the rubber tubing leading to the burners. Since the generator must be moved each time it is fillled, connection with it is made by flexible rubber tubing (o).

The flame is quite similar to that obtained from ordinary coal gas. It can be made luminous or non-luminous at will. The Bunsen burners, however, with some modifications, can be made to work very well. The opening through which gas is admitted to the base of the burner must be enlarged and the holes at the side of the tube for admitting air should be quite small. This I accomplished by slipping a perforated paper between the movable collar and the tube.



This generator is to be commended (1) for its cheapness. Twenty dollars will provide an elaborate apparatus, while a serviceable one can be constructed for much less. (2) It can be made at any tin shop. (3) It is safe. The flame cannot be drawn back to produce an explosion. I demonstrated this by experiments in the open air. (4) Its operation is economical. One gallon of gasoline will last for weeks. (5) There is no large volume of gas stored to leak and cause trouble, and no gas is generated except as needed. The apparatus is rendered absolutely inoperative by tying to a peg the rope leading from the pulley (k).

Note.—Since the meeting of the Schoolmasters' Club I have learned that burners are now manufactured which are especially designed for the gasoline flame. They can be obtained of houses dealing in laboratory supplies.

COEFFICIENT OF LINEAR EXPANSION.

C. S. COOKE, DETROIT CENTRAL HIGH SCHOOL.

The idea for the form of apparatus herein described was suggested to me by N. H. Williams, Shortridge High School, Indianapolis. After experimenting for some time with different pieces of apparatus for measuring the coefficient of linear expansion, I can safely recommend the one described below for its simple construction, small cost and reasonable accuracy, considering the several sources of error incumbent on any coefficient of expansion piece. Where there are several similar pieces of apparatus to be set up for a laboratory section, the time saved by having apparatus of simple construction is of considerable importance. With most pieces some electrical device is used for obtaining the expansion. Such devices are often unreliable in the hands of the pupil. Often times the frame work for supporting the metal tube or rod will expand with heat or moisture, thus introducing errors into the result. In this piece there are no troublesome electrical contacts and it is comparatively free from the other difficulty mentioned. With the piece described it is possible for the pupil to obtain several readings during the laboratory period. We have observed that results obtained by pupils are uniformly better than with any other apparatus we have tried.

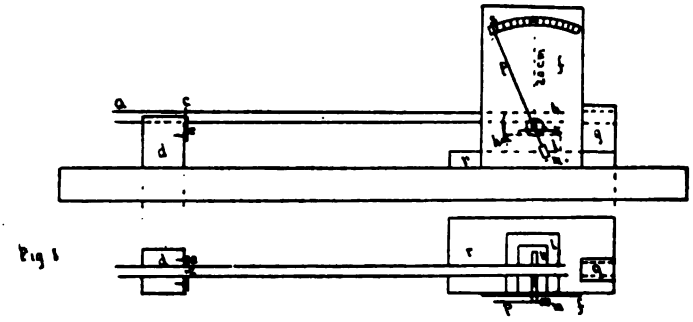


Fig 1

Fig 2

The apparatus consists of a brass tube (ab) about one meter long (Fig. 1) whose expansion is to be measured. One end of the tube rests in a grooved block (d) while the other end rests on a small brass roller (i) which carries the slender pointer (p). (m) is a counterbalancing weight. The roller rests on a piece of ground glass (k) which in turn is mounted on a block of wood (1). (1) is fastened to a small board (r). The ground

glass prevents slipping of the roller. (f) is a piece of cardboard or sheet metal fastened to the baseboard (r). The pointer moves in front of a scale (s) graduated in centimeters. The blocks (d) and (r) are firmly clamped to the table. A piece of gas tubing connects at (a) with a steam or cold water supply. The tubing at the other end passes through a hole in the block (g). This is to permit handling of the outlet tube during the experiment without disturbing any adjustments. The brass tube is kept in firm contact with the roller by a rubber band fastened to a tack at (h). The expansion takes place from the fixed point (c). A small pin passes through the tube and projects about 2 cms. of an inch from the under side and is securely clamped to the block (d) by a brass piece (e).

As the tube expands, the amount of expansion is measured off on the surface of the roller. This expansion bears the same relation to the movement of the end of the pointer that the diameter of the roller bears to the length of the pointer; thus in figure 2, E : S : : d : p. The shifting of the center of rotation introduces no error that is measureable.

We have tried covering the tube with a jacket to prevent errors by radiation, but do not find that the precaution is of any particular value.

The following tabular form shows the method of recording data and calculating results:—

Length of tube in cm	83.4 cm.
Diameter of roller (measured with micrometer screw)	.2402 cm.
Temperature of the water (taken at outlet)	3°.8 C.
Temperature of steam (computed from barometer)	99°.72 C.
Change of temperature	95°.92 C.
First position of the pointer	1.00 cm.
Second position of the pointer	13.49 cm.
Change of position of the pointer	12.49 cm.
Expansion (x : 12.49 : : .2402 : 20)	.1500 cm.
Expansion per degree	.001574 cm.
Expansion per degree per unit of length	.00001887 cm.
Accepted coefficient of expansion	.00001875 cm.

Error .00000012. Percentage of error, .6%.

SOME PHENOMENA OF HIGH FREQUENCY CURRENTS.

BENJAMIN F. BAILEY, ANN ARBOR.

The fundamental principle upon which the operation of high frequency apparatus is based, is the fact that the discharge of a condenser is usually oscillatory in character. In other words, if a condenser is charged and then allowed to discharge through a piece of wire, the current instead of flowing

steadily in one direction until all the energy is expended, oscillates rapidly back and forth a number of times. The case is precisely analogous to that of a pendulum or of a spring suddenly released from pressure.

Thus in Fig. I and II if we imagine an electric current, flowing in the circuit of I, and the pendulum in motion in II, the analogy between the cases is very striking. Thus the electro-motive force, driving the charge into the condenser (equal to Q C) corresponds to the force pushing the pendulum to one side (equal to $k\ s$). The back force due to acceleration $m\ (d^2q \div dt^2)$ takes the place of the back *E.M.F.* due to self-induction $L(dq^2 \div dt^2)$, and the force due to friction $K_2v = K_2(ds \div dt)$ that of the *E.M.F* due to resistance $RI = R(dq \div dt)$. Indeed the equations for the two phenomena are identical, and we can calculate the period of vibration of one as easily as that of the other. The theory is too long to give here, and I shall merely give two results of it.

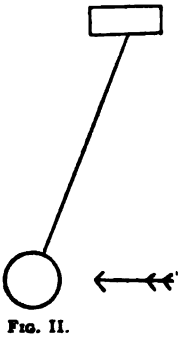


Fig. II.

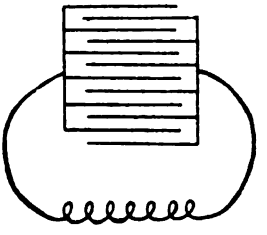


Fig. I.

One is that the period of one complete vibration of such a system is given by $T = 2\ \pi\ \sqrt{LC}$ comparable with $T = 2\ \pi \sqrt{(e \div g)}$ in the case of a pendulum), and the other is that in order to have any oscillation at all, it is necessary that the resistance be less than $2\sqrt{\ (L \div C)}$ just as in the case of the pendulum no vibration at all will take place if the viscosity of the medium in which it moves is too great.

The arrangement of the apparatus may be made in various ways, but the most usual set-up is as shown in Fig. III. T. is an ordinary alternating current transformer, charging a current of 50 volts and 120 complete cycles per second, to one of about 5000 volts, and of course the same frequency. This charges the condenser *C* with a certain quantity of electricity 240 times per second. In Fig. IV let the sine curve represent the variations of *E.M.F.* across the terminals of this first step up transformer. At the point *a* there is no *E.M.F.* applied to the condenser and consequently no charge in it. As the voltage increases along the curve *a e* the charge in the condenser also increases, and we finally come to the point *b* where the voltage is great enough so that the air gap *g* (Fig. III) breaks down, and allows the condenser to discharge through the primary *L* of *a* second step up transformer T_2.

This circuit of the condenser the spark gap and the primary of the second step up transformer is like that of Fig. I except for the resistance of

the spark gap and the discharge is consequently a high frequency current. This current is represented by *bdc* in which the length of the oscillations is greatly exaggerated on account of the difficulty of drawing them sufficiently close together. The number is probably greater than is shown there. From the secondary of this transformer we can draw a current like that in the primary except that the voltage is increased about 50 times, and the current decreased in the same ratio. This gives us in this particular machine a current of a frequency of 435,000 double vibrations per second, a voltage at the highest ordinate of 350,000 volts, and an average current of about half an ampere. This is a far greater output than can be obtained from an ordinary induction coil of the same size. The spark discharge produces a regular roar, so great is the volume of current.

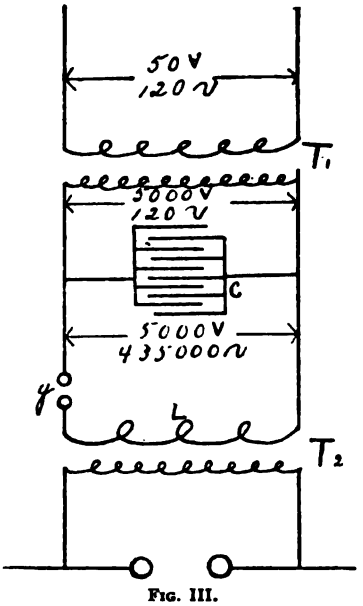


FIG. III.

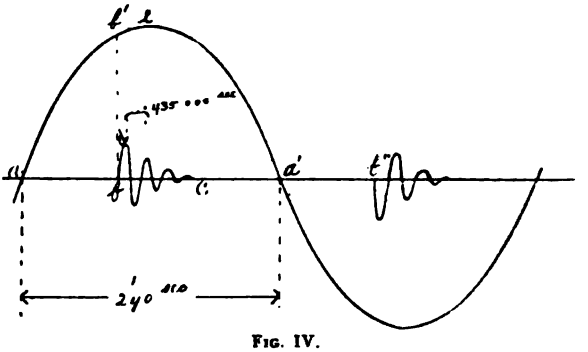


FIG. IV.

The high frequency and high potential transformer is of exceedingly curious and simple construction, compared with the ordinary induction coil. The primary consists of only four turns of heavy copper strip. This is wound upon a frame of wood, somewhat like a bird cage, only with fewer bars. The secondary has only a single layer of 200 turns wound upon a frame within the other one. Owing to the high frequency no iron core is needed; indeed its presence would be a serious detriment. Only about 350 feet of wire is used for the secondary, in comparison with about five miles which would be used in an ordinary coil of like voltage. The whole is immersed in oil to provide good insulation.

There is some liability of an ordinary alternating current arc forming across the gap *g*, and to prevent this a motor is used to rotate a toothed disc to break the arc., An air blast is sometimes used for the same purpose. The coil works nearly as well, however, with a plain spark gap.

We can now examine a little the results of our two equations. Taking the one for the minimum value of the resistance, $R < 2\sqrt{(L \div C)}$ and substituting the value of the self-induction and the capacity, we reach the interesting conclusion that the R is less than 17.2 ohms. Thus the actual resistance of the spark gap is certainly less than 17 ohms and is probably much smaller yet. To figure the frequency is quite simple. We have merely to substitute $T = 2\pi\sqrt{(L \div C)}$ and get for a result $T = \frac{1}{435{,}000}$ of a second or we have 435,000 complete vibrations per second. This enormous frequency is the distinguishing characteristic of the current, and is the cause of many strange effects.

Perhaps the most curious of these are its physiological effects. If we pass an ordinary alternating current through the human body, all the average person can endure without excessive pain is about 0.015 of an ampere. The resistance of the body from hand to hand between dry metal electrodes is about 2500 ohms. Then since the power expended is given by T^2K we have $0.015^2 \times 2500 = 0.56$ watt. In other words about half a watt of power applied continuously in the form of an alternating current of ordinary frequency is about all the human body can endure. What do we find to be the case with the high frequency current? As far as I can find nobody has ever constructed a machine capable of giving all the current a person can endure, so what the limit is we do not know.

The largest amount anyone has used as far as I can find out is 1.5 amperes, which is the maximum amount Elihu Thompson could obtain from his large machine. This means $1.5^2 \times 2500 = 5600$ watts or just one thousand times the amount of power that can be endured in the form of a low frequency current.

This is certainly a very surprising result, but it is not the worst of the case. By reference to Fig. IV it will be seen that there is an interval from c to b'' during which there is no current. Now the 1.5 amperes is the average (strictly speaking the $\sqrt{\text{mean}^2}$ value, but practically the average) value of the current during the whole time, and it is obvious that during the time from b to c it must be larger than this average. Still more, if we take the maximum ordinate as at d, it will be very much greater than 1.5 amperes. Just how much greater this is it is hard to say, but in any particular case we can approximate it so as to get at least an idea of the ratio. The argument is too long to give here but it leads to the surprising result that with an average value of 1.5 amperes the maximum value of the current is probably about 21 amperes. There are numberless theories regarding the harmlessness of these currents, but nothing is certainly known about it. The fact simply remains that there is not time between the very rapid oscillations for the muscles to respond and produce the painful contraction which is characteristic of the alternating current of low frequency. Also there is no electrolysis which is probably responsible for the painful effects of the direct current.

Another surprising property of these currents is the facility they give for what might be called "wireless lighting." If a glass globe, exhausted to the proper degree (a common incandescent lamp bulb will do, but a Geisler tube is better), be held near the high frequency coil, it will light up in much the same manner as though the discharge from an induction coil or a static machine had been passed through it. There need be no connection whatever between the tube and the coil. This is easily understood if we consider what would happen if we held a loop of wire in the same position. Some of the lines of force from the transformer would pass through the loop, and by their rapid change of direction would induce oscillating currents in the loop. Precisely the same thing occurs when we hold a bulb of rarefied gas there. Oscillating currents are induced in the gas in the same way, and it is these currents that cause the gas to light up.

This is an illustration of electro-magnetic induction. The same result can also be obtained by electro-static induction. If we connect the two discharge rods to two metal plates, suspended about a foot apart, we create between them a rapidly alternating electrostatic field of force. This is here called electro-static by courtesy only as it is in reality far from static. If we now hold or suspend a globe of rarefied gas between them, at one instant one plate will be positive, the other negative. By the law of attraction the + plate will attract — electricity to the end of the tube nearest it and repel + electricity to the other end. An instant later (in the case of the machine referred to $\frac{1}{870,000}$ of a second later) the conditions will be reversed and all the electricity attracted to the left of the tube must rush over to the right, and that on the right go to the left. This continues and thus an oscillating current is set up in the tube which causes it to light up.

As regards the application of high frequency currents in practical engineering, the outlook is not encouraging. There is no doubt but that such a system could be made to work (using the ordinary incandescent lamps in the usual manner, and not as described above), but several disadvantages would appear. The high frequency would make trouble on account of the capacity and induction effects, and the regulation would consequently be bad. The only saving would be in the cost of transformers, which, as was said before, would need no iron and very few turns of wire, and consequently could be built very cheaply. This is a comparatively small matter, however, and there is no likelihood of such an application in the near future.

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Proceedings

OF THE

Michigan Schoolmasters' Club

AT THE

Thirty-Ninth Meeting

HELD IN

YPSILANTI, March 31, April 1, 2, 1904

University of Michigan.

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Michigan Schoolmasters' Club

PROCEEDINGS OF THE THIRTY-NINTH MEETING, HELD AT YPSILANTI, MARCH 31, APRIL 1, 2, 1904

PAPERS

EDITED BY THE SECRETARY

GENERAL MEETING

SOME PROBLEMS IN EDUCATION.

PROFESSOR J. M. COULTER, UNIVERSITY OF CHICAGO.

Never in the history of education in America has there been such a universal movement towards change as now. Conscious that existing plans must be modified, all who are interested in education have a feeling of great unrest, and this feeling expresses itself at every educational conference. Discussions are endless, and often apparently fruitless, for opinions are as numerous as are the factors of the problem, and the mighty power of what has been over the frail form of what might be holds us with a death-like grip.

It is not probable that some great educational reformer will arise and lead us directly to the truth. In these days we are all searching for the truth so eagerly that it is not likely to come as a sudden revelation. It will probably come by a series of approximations, and it will not be recognized until it has been thoroughly tested; and when it is known and acknowledged no one can tell who has been responsible for it, for it will have been evolved gradually from all our former experience. There is no problem concerning which we can so ill afford to be dogmatic; and no one concerning which we are so dogmatically inclined. There is no question concerning which past experience may be so unsafe a guide, since what we have attained cannot be compared with what we hope for and have a right to expect. There is no problem in which theorizing may lead so far astray, and no problem which

has been so covered up with crude theorizing. We do not understand the structure we are seeking to modify and develop; we do not know what we want to do for it when we shall understand it; and we do not know how to accomplish when we shall know what we want. Out of this mass of negations we are constructing our hypotheses, and even venture to hope that they may stand. That student of education has not advanced very far into his subject who has any great measure of confidence in his own opinions, or in those of any one else. The effect of all this should be, not a discouraged, but a receptive mind; not dogmatism, but liberality. There need be no expectation that the true education is just at hand, and those impatient souls who cannot rest content until everything is settled must cultivate the scientific spirit, which has learned to labor and to wait. It is no less a fact, however, that the true education is nearer at hand than it was last year, and that its coming will be hastened in proportion to our dissatisfaction with the existing order of things, and our rejection of that mind benumbing dogma that the past contains all that is best in education. Our educational growth should be like that of a vigorous tree, rooted and grounded in all the truth that the past has revealed, but stretching out its branches and ever renewed foliage to the air and the sunshine, and taking into its life the forces of today.

With such a preface it may seem rash to suggest anything, but all of us must keep suggesting, if it is only the suggestion of a doubt. The subject announced is broad enough for me to select what I choose from the mass of educational problems that are constantly presenting themselves. If any of those which I have selected, or even all of them, do not seem pertinent to your situation, you must understand that for some reason they have forced themselves upon my attention.

The first problem I would suggest is:

1. *The act of teaching.*—This is quite independent of the subject-matter and has no reference to the equipment of the school in material things. It concerns simply the contact of teacher and pupil in the act of teaching. Perhaps the most difficult work of the teacher is to appreciate the exact mental condition of the pupil in reference to any subject. Unless there is complete adaptation in this regard the contact is a failure, leading to mutual disgust and distrust. It has been my good fortune to witness a large amount of teaching in all grades, and the impression left upon me has been one of astonishing lack of simplicity and directness in the presentation of subjects, resulting in utter confusion. My own conclusion has been that this indicates either ignorance of the subject, or lack of teaching ability, or a wooden application of some pedagogical refinement which has been learned somewhere, and which is either not worth applying in any case, or is woefully misplaced. Hardly can there be imagined a worse combination than wooden teaching by one ignorant of the subject. In a great mass of teaching, instead of using clear expression and a direct presentation, the effort seems to be to use most unusual phrases, as far from an ordinary vocabulary as possible, and to approach the subject in such a devious way that its significance is in danger of being missed. The philosophy of teaching is well enough as a background, but philosophical teaching is usually out of place. To inject

the abstractions and phrase-making of normal training into the school room is to dismiss clearness and all intellectual contact with pupils. This is no criticism of pedagogical training, for I would be the last to suggest that any profession should be attempted wihout professional training; but it is a criticism of those teachers who do not know how to apply their training, and follow what they regard to be rules, rather than principles. Probably the greatest factor in this result is the fact that far too many teachers have learned the form of teaching merely, and have strangely neglected to gain some knowledge of the subject-matter to be taught. With them it is form without substance, and what else are they equipped to do but to go slavishly through the motions of teaching? There is no flexibility, no power of adaptation, no ability to depart from a fixed routine, and hence no adjustment to the very diverse mental conditions they must meet and are expected to stimulate. Necessary flexibility in methods is impossible without a broad grasp of the subject to be presented. It should be unnecessary soberly to state that methods of presentation amount to nothing without something to present, but the schools seem to need the statement. The amount of meaningless drudgery that this senseless formalism has forced upon pupils has long been recognized by parents, whose indignation occasionally breaks out in condemnation of the schools as places where method has run to seed. It is very fortunate that the human mind is so tough a structure that it will develop in spite of teachers, and all of our educational experiments have not succeeded in sensibly stunting it. I have about concluded that the great problem in the act of teaching is not how to impart instruction, but how to oppose the fewest obstacles to mental development. The human mind has a mighty way of overcoming obstacles, but, as teacher, we have no right to attempt to make them insurmountable. I have almost cried out in indignation when witnessing some pupil whose quick mind has discovered short cuts to results, ruthlessly forced upon the procrustean bed of method by some teacher who knows only one way. It is such things that bring the profession into deserved contempt, as one that has not yet emerged from blind empiricism.

The necessary combination of knowledge of the subject with knowledge of methods needs further emphasis and application. It is often supposed that the lower the grade or the more elementary the subject, the less the need of a knowledge of the subject on the part of the teacher. There can be no greater mistake if successful teaching is the end in view. In no part of educational work is flexibility in presentation and in material so necessary, as at its very beginning. Truth is many-sided, and it is always a question as to which side shall be presented. The teacher who only knows one side is hopelessly lost, and hence becomes dogmatic and useless. For instance, I know of no science teaching that demands a broader grasp of the subject-matter, and a more facile adaptation of material to purpose, than "nature study" in the lower grades. So long as it is committed to teachers with no scientific training, I predict that it will be a failure. It is in danger of becoming worse than a failure, for to atone for lack of scientific knowledge teachers are apt to have recourse to popular books upon science, full of sensational and claptrap statements, and actually mislead those whom they

are guiding. To escape from the bondage of the book, to see with our own eyes, to handle with our own hands, to judge for ourselves, cannot be brought about by the retailing of romances. Even if the teacher has enough of the scientific spirit, to say nothing of sufficient knowledge, to discard the romances, the overwhelming danger is that the pupil will be set at dead work, which when done leads to nothing. Observation merely for the sake of obervation is cruel when the world is full of important things to be observed. But how can a teacher select the important things and discard the trifling things without some fundamental knowledge of the subject? The whole race of man is peculiarly open to humbugging in the guise of science, and this will be intensified if school children are to be humbugged by their teachers. I have used as an illustration a subject with which I happen to be familiar, but fancy that it is but an illustration of all the rest. Not to prolong the discussion of this particular problem, it is my desire to impress the fact that the act of teaching demands a knowledge of subjects as well as of methods, that there may be the greatest amount of flexibility in presentation; it demands simple language and a very direct style; entire suppression of the philosophy of a subject until there are facts enough upon which to found a little simple philosophy; complete abolition of all pedagogical cant; and a reverence for truth that will not permit it to be trifled with in order to arouse a factitious interest.

My next problem is much more special, but it has long been a troublesome one, and has a certain logical connection with the one already considered. It is

2. *Science in secondary schools.*—Probably no subject has been more discussed than this one, and it seems well-nigh threadbare. School-teachers and university-teachers, in committees and conventions and addresses and periodicals, have wrestled with this problem. The school-teachers knew their pupils and their facilities, but not too much about the subjects. The university-teachers knew the subjects but very little about the pupils, and still less about the facilities. It was hard for both to occupy the same standpoint, and both were inclined to be somewhat dogmatic, the university-teacher, perhaps, a little the more so. School patrons with their demands have been a factor also. The result is what you see, and very far from satisfactory, for neither university-teachers, nor school-teachers, nor patrons can be said to be satisfied. There seems to be well nigh general consent to reduce the number of subjects masquerading under the name of science, to restrict them to a few fundamental ones, to increase as much as possible the time devoted to each one, and to insist upon the laboratory as an essential adjunct. This is advancing very far in what we believe to be the right direction, but it is more an advance in opinion that in practice. It does not become me to particularize concerning all the sciences, but I wish to make a few suggestions concerning that one with which I am identified, and the principles stated may be capable of application to all the rest.

Among the fundamental sciences botany finds a prominent place, as presenting material everywhere present and easy to handle, as entering largely into our every day lives, as peculiarly adapted to serve the variety of pur-

poses in view in a science study. As this science has been revolutionized within a few years and is still in a period of extreme revolution, the schools have found themselves strangely at variance with the universities, and are plainly and repeatedly told that their botany is an absurdity. These unpleasant statements are usually received with becoming meekness, as coming from those who are supposed to know, but have led to nothing or to chaos. The ancient type of botanical teaching, lineal descendant of the time when botany was regarded as more æsthetic than scientific, was to regard the flower as the only material worthy of examination, and the name of the plant which bore it as the ultimate fact to be learned. All consideration of plant organs was limited to their usefulness in helping to obtain some trace of this all-important name, and botany became a somewhat elaborate game of hide-and-seek. Interested publishers supplied the school with "analytical keys" for chasing the delusive name; ingenious teachers and others devised analytical blanks, in which the fleeting observations could be set down, and by which all impertinent observations could be suppressed and the observer turned into a counting machine; herbariums began to be demanded, whose value was measured by the names tagged to the specimens. Is it a wonder that botany came to be regarded as a collection of not especially attractive names? There is no doubt that such work found a ready interest in certain pupils, and that botanists have been born out of just such conditions; but the chief complaint is that this is not botany. It holds about the same relation to botany as does a collection of postage stamps to geography. The universities, after they had learned a little botany themselves, rose up and condemned this masquerade, and the universities did well; but what did they seek to substitute for it? The schools were told that a laboratory must be equipped with compound microscopes; that botany could be seen only by peering through a lens; that all the plant groups, from the lowest to highest, especially the lowest, must be passed in review. It was urged that by this method alone could there be gained any proper conception of the plant kingdom. The schools, as many as could command the specified equipment or believed in the advice, made the change. Young men and young women fresh from university laboratories were called upon to direct the work, and the schools waited to be revolutionized. It was of intense interest to me to watch the result, since my own voice was as loud as any in recommending the change, and it had the entire consent of my judgment. Numerous new books appeared, both text-books and laboratory guides, the favorite legend being "for high schools and colleges"; this time written by the college men, and, as the school-teachers soon learned, from the college standpoint, which calculates upon time and equipment and a reasonable amount of intellectual maturity. The schools began the struggle and they have been struggling ever since. I have visited numerous high schools to inspect their work in botany, schools that contain the best possible facilities for this kind of work, and I wish to give the result. Taking an excellent school as an example, I found it equipped with laboratories that put to shame those of many colleges, and the work in charge of thoroughly trained special teachers, competent to get the best results possible. The plant kingdom must be presented

in four or five months. The congested state of the schedule, however, a perfectly normal state in secondary schools, permitted only two exercises each week. Some thirty or forty exercises, therefore, of one or two hours each, represented the actual time at command. It should be said that the instructors rebelled both at the time and the field to be covered, but a Juggernaut system must override all such protests, and the result must be demanded without any reference to conditions. The plant kingdom, therefore, was marshalled through its representatives; fleeting glimpses of unknown and unrecognizable things were obtained through the microscope; that most difficult art of interpretation, without which the microscope is but a delusion and a snare, could not be cultivated; a rapid succession of unrelated objects, becoming increasingly complex and hence more difficult of interpretation, was presented in bewildering haste; the brief lectures dealt with the most fundamental and philosophical truths of biology. At the completion of the course I conferred with several of the brightest pupils and sought to discover their knowledge of the plant kingdom. It was simply confusion. Undoubtedly, there are a few favored schools where a more liberal management can show better results, but I believe that the result given is the general one. Therefore, I am ready to confess, contrary to my former honest conviction and earnest contention, that the universities made a blunder in their advice. The old method was very narrow, and very superficial, but it gave a certain kind of contact with nature. The new method is broad and philosophical, but it withdraws pupils from contact with nature and makes botany a thing of the laboratory table and the microscope. The latter needs time and some maturity, as well as equipment, to develop. There is still another phase of botany, which is coming rapidly into prominence and which is reaching sufficient organization to be utilized by the schools, which I believe is destined to be the field cultivated by secondary schools. It has all the breadth and philosophy of the morphological work that is being attempted, and a much more rational contact with nature than the old method of so-called "analysis" brought. While it is often claimed that studies are merely tools, to be thrown aside when the result has been obtained, there are certainly some subjects at least in which the content as well as the discipline is to be considered. It is very important, for example, that the pupil at some time shall come into rational contact with the phenomena of life, as presented by plants or animals or both, and this quite apart from the discipline such study is adapted to afford. These phenomena enter too much into the necessary experience of everyone to be disregarded in schemes of education. It is such a contact that the new botany brings. Plants are regarded as living things, performing a variety of operations, sensitively adapting themselves to varying external conditions, associating themselves into communities of various kinds, occupying a definite place in nature. This mass impression of plants as a whole, and of the conditions which determine their distribution and association, is the fitting introduction to more detailed study. The main trouble with the morphology work of our schools to-day, and of many of our colleges as well, is that the structures observed cannot be related properly. There is no background upon which the

details can be projected. The substitution of intelligent field-work, not collecting, for some of the laboratory work, the introduction to plant societies and the recognition of their peculiarities, the constantly deepening impression that plants are things which work as well as exist, which perceive and having preceived respond, must certainly commend itself as resulting in a worthy primary impression of the plant kingdom. It is not the superficial search for so-called flowering plants and their names; it is not the monotonous treadmill of morphological work and microscopical examination; it is that which gives significance to both, and introduces plants as living, sensitive, responsive organisms; not scattered at haphazard, but organized into communities with all sorts of mutual relations, and giving significance to every landscape; not passive and helpless, but exceedingly active and able to take care of themselves; not things to be used and admired merely, but also the great revealers of those fundamental laws of biology whose study is to lead us eventually into the deepest recesses of knowledge. The principle involved is to lead to a correct impression of general truth by means of personal contact, from which advance in any direction may be made. The preparation for such teaching is not easy, but I have long since given up the impossible task of devising some method of teaching botany, or anything else, that can be used by teachers who know nothing of the subject. The teacher who knows nothing of his subject is necessarily a failure, and it is perfect folly to try to prop him up. There is nothing for him but to stop the farce, and either learn something to teach or seek some other employment.

It must be confessed that much of the trouble with science in the secondary schools has come, not simply from teachers who know no science, but often from the lack of pedagogical instinct that compels them to adapt their training to school and pupils. They seek to establish a minature college laboratory, a laboratory peculiarly ill-adapted to school conditions. It seems to be a hard lesson for university graduates to learn, who undertake to do secondary-school work, that a secondary school is not a college, and that it demands its own peculiar kind of teaching. Slavish repetition of college work in the secondary schools is necessarily a failure. The college supplies knowledge of the subject, and the general spirit which should pervade it, but it should never be taken as an exact model for the secondary school.

3. *Nature study.*—In the same connection I wish to speak briefly of "nature study." At first sight it may seem to have little to do with the secondary schools and colleges, but from my point of view it is a subject of vital importance to the whole scheme of education. Although formally mentioned only in connection with the lower grades, it underlies the possibility of future work, and its absence accounts for the strange inequality in numbers observed in the later years of training between those with scientific tastes and those without. Any educational scheme which for years persistently excludes any phase of work must expect a comparatively small response when it is finally offered.

Under this somewhat comprehensive title of "nature study" there has entered the schools an element of teaching so fresh and vivifying, that it has come as a revelation, and will certainly work a revolution. The average

school curriculum, fairly riveted upon us by long years of precedent, seems to be established upon the idea that education consists in the presentation of subjects totally unrelated to the experience of the pupil. This conception of education could only have been held before there was a science of education founded upon some knowledge of the mental processes of the child. Since such a science has come into existence, and has begun to accumulate its facts, we have learned the absurdities of empiricism and of speculation in education, and have turned with hope to experimental psychology. Our results are comparatively few, as yet, but they are sufficient to give us some insight into the child's mind and to recognize the warping and benumbing treatment it has been receiving. We are passing from the days of pills and potions to the days of hygiene, and are seeking not to rack the mind but to preserve its normal tone. One of the first visible mental tendencies in the child mind is the spirit of inquiry aroused by natural objects. The tendency is well known, but the natural keenness of observation in the normal child was a revelation even to those who were suspecting it. By keenness, I mean rapidity and accuracy and completeness of observation. These normal children have been passing into the schools; their attention, under compulsion, has been withdrawn from what were realities to them, to the abstractions of language and numbers; they were asked to think, but not as a result of observation; the conventional completely supplanted the real; there was thinking, but no independent thinking; the fine tentacles which were born with them finally became atrophied through disuse. When years later they are introduced to some observational science work there is a clumsiness of effort, a lack of spontaneity, an overwhelming sense of strangeness that is pitiful to see. Hundreds of such cases have I seen, and so completely has the school done its work that only here and there can a few be found whose old natural power can be in a measure restored. We have been taking a normal, healthy, powerful, God-given impulse of the human mind and have ruthlessly maimed and crippled it. The result may not be so obvious as the maiming of feet practised by Chinese women, but it belongs to the same category and is infinitely more cruel. Into this condition of things nature study came, and it met the greatest need in the education of children. It is difficult work, very difficult work, and a blunderer may make a sorry showing, but so he will in anything that takes training and judgment. It meets the child on the threshold of school as the one familiar face. It satisfies and keeps active important powers to whose trained service he is entitled throughout life. It relates his school life and hence all his life to the great world of nature about him, full as it is of wisdom, of pleasure, of comfort, to those who can see. I cannot understand how we were ever so educationally blind as deliberately to eradicate nature from the lives of children and to send them out into a world robbed of half its significance.

It may be well to make a somewhat definite statement of the principles that should obtain in "nature study," and I wish to preface this by a few criticisms upon observed methods. It must be confessed in the outset that nature study as yet is largely in the hands of unprepared teachers, who have had it thrust upon them, and who are more or less conscious of their helpless-

ness. Further, quite a number of the reputed leaders in the subject are distinctly "blind leaders of the blind." As a consequence, nature study today is an ill-defined, inchoate thing, the despair of the primary teacher and the joke of the scientific fraternity. And yet, its purpose is sound, and it is bound to outgrow its youthful ailments. It is certainly a great problem, to be solved by extensive experiment rather than by preconceived notions. All statements of principles, such as I am about to make, must be regarded merely as statements of working hypotheses, until they are established or set aside through experience.

My first criticism of observed methods is directed against what I have been in the habit of calling "dead work," which means the observation of insignificant, trivial things, work that means nothing when it is done. I realize that many a teacher, through lack of knowledge, is compelled to occupy the time with anything that occurs to her, and sometimes she is honest enough to call the exercise "busy work." For example, I have seen period after period given to the study of forms of leaves, chiefly because the forms are endless, and illustrative material is easily obtained. It would seem to be a crime, except that the criminal intent is lacking, to waste a pupil's time with meaningless observations when the world is crowded full of important things waiting to be observed. Of course it demands a little knowledge on the part of the teacher to distinguish between the important and the trivial.

A second criticism of observed methods is the attempt to arouse a factitious interest in nature study by all sorts of playful and imaginative devices. Most of the books dealing with nature study cater to this tendency, and perhaps are largely responsible for it. These devices disgust strong children, just as does the foolish and forced sprightliness of many primary teachers. The whole business is as confusing and benumbing as "baby talk." But the serious point is that "nature study," imbedded as it is in conventional education, is the one chance for exact and independent observation, for cultivating the ideas that between cause and effect there can be no hiatus, that imagination is beautiful and most useful in its place but that its place is never to lead to a misconception of facts, and that there should be no playing fast and loose with truth.

It seems to me that a fundamental statement concerning nature study is that it is to keep functional what I have called the "tentacles of inquiry." It follows that a test of success is *interest*. It is evident, therefore, that no science can be presented in any completeness or in any definitely organized sequence, and hence the purpose must be *continuity of interest* and not *continuity of subject*. The resulting interest must be checked by the objects of interest, which must be important, and so I reach my general thesis that *nature study must look to a continuity of interest in important subjects.*

What are appropriate subjects? I would suggest an answer under three heads: (1) *Things of common experience.* This means that there can be no fixed schedule appropriate for every school, and it also means an adaptable teacher. The teacher who has secured a definite "outline" from some one is in danger of passing by the most important natural objects

within reach of the schools. I have seen such an "outline" prepared on the seacoast and being used by a teacher in the central west. When it came to the subject of seaweeds, a few miserable things were obtained with much difficulty from the seashore, and the glorious forest with which the school was surrounded was left without observation! This is an extreme case, but essentially the same thing is common enough. (2) *No subject should be pressed too far,* for interest may pass into disgust. Watch the pupil, not the outline! (3) *Observation should be directed more toward activity than towards form and structure.* It is fundamental in botany that plants be regarded as things alive and at work; and it is also of far greater interest to a child to watch a plant doing something than to observe form and structure, which in the very nature of things mean nothing to the observer.

What are appropriate methods? (1) Very definite work, that has already been traversed by the teacher; for it is confusing and discouraging and disastrous to work at random; some very definite result must be plainly in sight; (2) individual work in observation or experiment, which means personal responsibility; (3) unprejudiced observation, which means that the pupil is not to be told what ought to be seen; some children are so docile that they never fail to see what they are told to see; (4) bringing together and comparing individual results, a thing of fundamental importance, for it develops differences in results which must be settled by repetition, shows what is essential in the results and what amount of variation is possible, develops the habit of caution in generalization, and impresses the need and nature of adequate proof.

What are the appropriate results? (1) A sustained interest in natural objects and the phenomena of nature; (2) an independence in observation and conclusion; (3) some conception as to what an exact statement is; (4) some conception of what constitutes proof; in short, an independent, rational individual, such as the world needs today more than anything else. I feel strongly that our educational system lacks efficiency in just this direction, and that continuous training in exact observation and inference, beginning with the kindergarten, must result in more sanity among adults.

There seems to be abroad a notion that one may start with a single well-attested fact, and by some logical machinery construct an elaborate system and reach an authentic conclusion, much as the world imagined for more than a century that Cuvier could do if a single bone were furnished him. The result is bad, even though the fact may have an unclouded title. But it too often happens that great superstructures have been reared upon a fact which is claimed rather than demonstrated.

We are not called upon to construct a theory of the universe even upon every well-attested fact, and the sooner this is learned the more time will be saved and the more functional will the observing powers remain. Facts are like stepping stones; so long as one can get a reasonably close series of them he can make some progress in a given direction, but when he steps beyond them he flounders. As one travels away from a fact, its significance in any conclusion becomes more and more attenuated, until presently the vanishing point is reached, like the rays of light from a candle. A fact is really only

influential in its own immediate vicinity; but the whole structure of many a system lies in the region beyond the vanishing point.

We must wonder what lies beyond, we must try our wings in an excursion now and then, but very much stress must never be laid upon the value of the results thus obtained.

Such "vain imaginings" are delightfully seductive to many people, whose life and conduct are even shaped by them. I have been amazed at the large development of this phase of emotional insantiy, commonly masquerading under the name of "subtle thinking." Perhaps the name is expressive enough, if it means thinking without any material for thought. And is not this one great danger of our educational system, when special stress is laid upon training? There is danger of setting to work a mental machine without giving it suitable material upon which it may operate, and it reacts upon itself, resulting in a sort of mental chaos. An active mind turned in upon itself, without any valuable objective material, can certainly never reach any very reliable results.

It may not be that nature study and laboratory science in education are the only agencies, apart from common sense, that are correcting this tendency, but they certainly teach most impressively, by object lessons which are concrete and hence easiest to grasp, that it is dangerous to stray away very far from the facts, and that the further one strays away the more dangerous it becomes, and almost inevitably leads to self-deception. It is from such a fate that people must be saved, and the time to begin is in the primary school, with nature study from which imagination and emotion are largely eliminated and the pupils are held rigidly to the facts.

4. *The schools and the universities.*—This problem, so far from being solved, is getting into a condition so involved that its future status is very uncertain. Questions of entrance requirements, of examination or certificate, represent the border line problems that interest schools and universities alike. As a rule, so far as the high schools are concerned, the state universities have determined these standards, and as a rule the other universities, in self defense, have followed them. From the standpoint of the university, the high school exists to prepare university students. From the standpoint of the high school, its primary function may be somewhat different. The university, and especially the state university, cannot afford to disarticulate itself from the rest of the school system; on the other hand the high school cannot afford to lose the uplift of the university. Universities, as a rule, are great storehouses of educational precedents, which have descended from mediæval times, when there were very few subjects organized for study, and these few held little or no relation to the problems of intelligent living. They were the possession and pastime of a favored few. Heredity has filled the blood of most universities with this so-called scholastic spirit, so that they find it hard to adapt themselves to the new conditions. The cut of one's education has come to be as formal as the cut of his dress coat. It should be remembered that the old selection of subjects was a matter of necessity rather than of choice; but since the opportunity for ample choice

has come, the old necessity no longer exists, although it is the tendency of most universities to regard the older subjects and the older methods as possessing a peculiar relation to education. On the other hand, the American school system is peculiarly a modern institution, developed out of the necessities of our own civilization, and seeking to meet the demands of the time. The schools are handicapped by no precedents, and have no heirloom rubbish to intercalate among their modern furniture. To the thoughtful student of education it is intensely interesting to watch the progress of the effort to articulate the very old, as represented by universities, with the very new, as represented by schools. It was necessary that it should lead to clashing opinions, and that the old and the new should mutually scoff at one another. The old had the advantage of that dignity and influence which belong to years and an honorable history; the new had the advantage of numbers and public opinion. Neither could dictate to the other, though both wanted to. It is really quite remarkable that the two have gotten along so well together, and this argues well for the deep-rooted belief of each that it must have the other. In the main, however, the universities have imposed more upon the schools than they have conceded; as is very apt to be the case when the weight of educational authority is largely upon one side. It is hard for the universities to lay aside the thought that the high schools are primarily preparatory schools. If this be conceded, then the universities must be permitted to dictate the courses of study. But it is not conceded, and still the universities have in effect dictated the courses. They have done it by making the entrance requirements so specific and so numerous that the four years of high-school are absolutely filled with them. If there is anything for a high school to do besides preparing students for college it either has no time for it or is compelled to organize a separate and independent curriculum which does not lead to college. Most schools are so situated that they cannot do both. The colleges are honest in their opinion that their entrance requirements represent the very best education for a student of that grade whether he is to enter college or not. I have helped express and enforce this opinion, and so cannot be accused of any undue prejudice if I now venture to dissent from it. I still think that a large part of the university entrance requirement represents the very wisest subjects that can enter into the curriculum of the high school; but when these requirements become so large and so specific that they destroy the educational autonomy of the high school, and convert it into a university appendage, then I am constrained to dissent. The increasing standards are to permit more advanced work in the university, and this is a magnificent purpose, to be encouraged by every true lover of education; but it must not be done at the expense of schools the great mass of whose students never enter the university. It is wise to introduce into the high school studies which may be of no special benefit to the pupil preparing for college, for they are of great benefit to the lives of those whose educational career must end with the high school. As I understand it, the high school is intended to train for better citizenship, to enlarge the opportunity for obtaining a better livelihood, to open broader views of life and its duties. In order

to be of the greatest benefit to the greatest number, its course of study must be constructed as though there were to be no further formal education for the pupil. Subjects must be related to the needs of life and of society, but this need not and should not exclude those subjects or those methods which prepare and stimulate for further study, for there should be constant recognition of the fact that the secondary school is but an intermediate stage in educational progress. I regard the recent tendency of universities to increase their demands upon the schools as unwise, and as fraught with danger. It has long been my theory that the specific demands may be very few, and these so self evident that a school would not be likely to omit them. What the universities need is not a specific kind of preparation, but a certain degree of intellectual development, a development which is usually much broader than that obtained from the average college preparation. I may be allowed to say, as the result of many years of experience, that this average college preparation presents to the universities the most narrow and unevenly trained material that can be imagined. Nowhere are the evils of specialization so apparent as in the entrance preparation demanded by most colleges. If this specialization results in comparatively poor college material, its results may be regarded as simply disastrous to the high school in its primary purpose. This is not a plea for the multiplication of studies in the high schools, for one of their great weaknesses today is their tremendously congested condition. It is a plea for the relief of this congestion by reducing the university demands, not in quantity, but in specific assignment, leaving the schools freer to exercise their own judgment in the selection of special subjects. The time has long passed when any aristocracy of subjects has any right to claim the privilege of standing guard over every avenue leading to a higher education. Any student who has successfully pursued a well-organized and coherent course for four years in a high school should be able to continue his work in the universities. There are differences of opinion as to what constitutes a well-organized and coherent course, but it could be outlined by principles rather than in detail, and the schools themselves should be responsible for its construction. A minimum of subjects and a maximum of time, continuous rather than scattered work, a range broad enough to touch upon all of the fundamental regions of work, methods that will secure precision in thought and expression, contact with the life and work of the times in which we are destined to live, are certainly principles that are sufficient, but concerning whose details none should dogmatize, for they may well vary with the teachers, and the local conditions. For instance, to require botany, when the teacher is far better equipped for zoology, is simply nonsense, an illustration which finds its parallel in every region of work. The university should always be called upon for advice as to courses and methods, but it should be from the standpoint of the schools, a standpoint best determined by the schools themselves. For instance, I would not presume to dictate to any school the way in which botany must be taught; but I would count it a privilege, upon being made acquainted with the preparation of the teacher, and the facilities at command, to suggest certain

lines of work, from which as a rational being, knowing the condition better than any one else, he could make his choice. I would regard it as my chief function to guard inexperience against waste of time and energy, rather than to specifically direct. If the teacher did not know enough to make a choice in such matters, I would advise the selection of some other means of making a living. I must confess to being a great stickler for individual independence and responsibility, and that school or that teacher which is held in the dictatorial grasp of some higher authority which permits no expression of individualism in methods, which sternly represses all spontaneity and originality, which demands an automaton-like service, is pedagogically blighted. The vast machinery of the schools which enters into every petty detail, rides them like the old man of the sea, and is converting schools into factories, and teachers into drudges.

And how shall well prepared material be recognized at the university? Lately the entrance examination system has thrust itself upon my attention afresh. I do not know whether this ghost of a dead past stalks into your educational banquets or not, but it is rampant in certain universities that rather pride themselves upon being haunted. A better scheme to show how not to do it was never devised. At the present day it is peculiar to the Chinese theory of education, and that nation should be allowed its exclusive use. It is both barbarous and unscientific. I would make no serious objection to its barbarity, if it were scientific, that is, if it obtained the information it seeks. What teacher does not recognize that the estimate of the ordinary examination must be tempered by knowledge of the daily work, or grave injustice may be done? How much greater the need of this tempering in the extraordinary entrance examination! If the tempering is necessary to obtain the facts, why not substitute the tempering entirely for the examination? Which means, of course, the substitution of the daily knowledge of the teacher for the ignorance of the university examiner. I wish no better evidence concerning the intellectual equipment of a candidate for entrance into a university than the judgment of the teachers with whom he has worked, for I can get no better, nor any other half so good.

It is strange that the universities are more concerned about their raw material than about their finished product. If they would be a little less sensitive concerning entrance requirements, and a little more particular concerning graduation requirements it might be a better expenditure of energy. It has always seemed to me that the fine-meshed sieve is set at the wrong end of the university.

In conclusion, it must be repeated that no complete change in these matters which I have presented, and in others of equal importance, can come suddenly. We can be dissatisfied with the results, and can point out defects here and there which in our judgment are responsible for them, but certainly no single opinion should be followed. The subject is too vast in its importance and in its ramifications to be grasped by any one man. Its many sides confound our best judgment. It is always easy to rail at the existing order of things in a pessimistic way, and such railing is only productive of

evil. But criticism, born of intense love for the cause of education, and longing for its best development, is always helpful. Such thoughts are at work like leaven, and when they shall have permeated sufficiently, movements will begin, quietly and moderately it is to be hoped, but persistently, and out of the movements there will slowly arise new methods, which upon trial have met with general consent. No student of our educational institutions can fail to observe that the general progress towards better things has been recently very rapid, probably as rapid as is safe for wise organization. We can afford to be optimistic at the outlook, and need only concern ourselves with recognizing and attacking the points of weakness, some of which always exist to give us occupation. There is within our educational system, not perfection, unless it be in its ultimate purpose, but a wonderful power of endless development. We are to establish an American system of education, not copied from ancient times or other countries, but drawing from them all that is appropriate, and adding our own ideals, we are to meet conditions for which we find no precedent. To such great service are you called, and it will demand not only your enthusiastic and unselfish devotion to the cause of education, but your best thought and calmest judgment as educators, and your most competent work as teachers.

OVERPRESSURE, ANCIENT AND MODERN.

W. H. PAYNE.

In the Capitoline Museum in Rome there is one large hall devoted to odds and ends, the *disjecta membra* of many pieces of sculpture. Occasionally an entire piece has escaped the graver accidents of time and has come down to us nearly intact. There is such a piece crowded close to one of the walls of the hall, and made almost inaccessible by statues of indifferent merit standing before it.* It is a funereal monument that would naturally appeal to a schoolmaster's heart. It is about four feet in height, three in breadth, and two in thickness; and in the niche in front there stands the statuette of a Roman schoolboy holding a manuscript in his left hand. On the base of the monument there is a Latin inscription giving us a lamentable account of the untimely fate that befell this poor boy, Sulpicius Maximus, in his twelfth year.

The Emperor Domitian was a promoter of learning, having, among other things, called Quintilian to direct the education of his grand-nephews.

*Through the good offices of expert photographers, I secured two good views of this monument and an excellent copy of its inscriptions, Greek and Roman, in papier-maché.

Availing himself of this material, Mr. J. Raleigh Nelson wrote the interesting article entitled, "The Boy Poet, Sulpicius—A Tragedy of Roman Education," which was read at the last meeting of the Schoolmasters' Club, and published in May, 1903, in *The School Review*.

Greek learning had become fashionable in Rome, taking precedence over Latin in the discipline of the schools. In order to promote the new learning, the Emperor offered a prize for the best improvised piece of Greek verse. There were fifty-two contestants, and among them the boy Sulpicius. The occasion was one of unusual character. Success meant the approbation of the Emperor, and possibly some form of preferment. Excitement ran high. As we may suppose, emotion was tense; mind and brain were overtaxed. The boy finished his poem, but the effort cost him his life. This monument was the parents' tribute to the memory of their lost son, and the Greek verse that was the occasion of his taking off, is carefully inscribed on the sides of this commemorative marble. Had the inscription been written in our vernacular it might have stood:—

SULPICIUS MAXIMUS
Died of Greek verse
In his twelfth year
Farewell! Farewell!!

What happened in the case of this Roman student is no doubt typical of what happened in many other cases, and justifies us in saying that overpressure was a school disease in ancient as well as in modern times, though there are reasons why this disease is more prevalent now than then.

During the years of my superintendency it not infrequently happened that complaints reached me from parents that their children were being overtaxed with work, to the great injury of both mind and body; and it was not a rare occurrence that reputable physicians entered formal protests against what they believed to be an evil of great magnitude, contending that permanent injury was likely to befall pupils from the senseless practice of cramming. Very naturally my sympathies were with the teachers as against parents and physicians, my professional loyalty seeming to require me to discount the alledged evils. Subsequent experience and a more judicial view of the facts in the case have convinced me, that, in the main, parents and physicians were right, and I and the teachers wrong.

I think it may be said with soberness and truth that in our secondary and higher institutions of learning the exactions made of students in the way of imposed tasks, virtually compel them to violate every principle of school hygiene. For example, Alexander Bain states* that there is a natural antagonism between an active brain and an active stomach, and that for this reason intellectual work should not be undertaken until two or three hours after the morning meal; but the practice of our schools makes it virtually impossible to pay heed to this primary hygienic law. In this brief paper, I am not so much concerned with the hygienic aspect of cramming as with its sinister effects on the intellectual life.

In a notable paragraph in his *Education*, entitled "Mental Strain," Mr. Spencer makes the following statement:—"It [cramming] is a mistake, also,

**Education as a Science*, pp. 12, 26.

QUINTUS SULPICIUS MAXIMUS

inasmuch as it assumes that the acquisition of knowledge is everything, and forgets that a much more important matter is the organization of knowledge, for which time and spontaneous thinking are requisite. * * * * It is not the knowledge stored up as intellectual fat which is of value, but that which is turned into intellectual muscle."* Time and spontaneous thinking! Who has ever known a college student who had time for such thinking, that is, that leisurely thinking which is involved in rumination, or the analysis and assimilation of knowledge? In the learning process there are two modes of thinking which should be sharply distinguished. In one case the mind is forced to work at high tension; while in the other, it is allowed to work at low tension, following its automatic bent. The first mode is seen in what is called drill or discipline; the second in what are called culture subjects like literature or history, where the purpose is the elaboration or organization of knowledge. A drill subject like algebra loses its proper education value when taught by the discursive or low tension method, while a culture subject loses its peculiar charm and value when taught by high pressure methods. Both modes of procedure are correct in their place, but wrong when transposed. When knowledge is to be organized, that is, transformed into structure, the movement of the mind is of the automatic or spontaneous order, in which the indispensible element is time.

It seems to be quite generally assumed by teachers that the aim of school instruction should be discipline or training. I fancy such teachers have been led astray by a false etymology. How many well intended but profitless homilies have been uttered on the magic or mystic virtues of *educre!* In the first place the derivation of the term *education* from *educre* is doubtless a mistake. The proper derivatives would be *eduction* and *eductor.* The root idea in *educre* is leadership, and not *drawing out,* as alledged. The fundamental and characteristic idea in education is nurture, the proper derivation of the term being from *educare,* meaning to nurture or to foster, education being the act of nourishing, and educator one whose function is to nourish. A school is to be judged not by the few who survive the rigors of its discipline, but rather by the many who profit by its nurture. †

Sometimes the best way to make progress is to return towards an abandoned ideal. According to the Greek conception, school is a place of leisure; and according to the Roman, a place of enjoyment or of play, but in our day there is nothing farther removed from recreation and leisure than our high pressure schools.

The evil I am criticising consists in focusing the mental powers on the process of accumulation, leaving them little or no leisure for the work of

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**Education* (Bardeen), p. 286.

†*"The school must nourish the souls of its pupils,* and the only nourishment possible is ideas. There may be other tasks—there are; the soul must be exercised and trained as well as fed; but the feeding is the first and essential thing, and the richest food of all—that which best of all builds up moral fibre—is the humanistic food that comes down to us from the past in the form of fairy tale, biography, history, and literature."—F. H. Hayward, *The Secret of Herbert,* p. 71.

organization, for which, as Mr. Spencer declares, time and spontaneous thinking are requisite. The years of college life are made too largely a grazing period, in which there is but little opportunity for rumination or meditation. The question I raise is whether a milder stress should not be placed on the process of accumulation, so that, during his college course, the student may make some substantial progress in education proper. I have wondered whether some beneficent millionaire of the Carnegie type might not endow an institution which in its programmes of study would make ample provision both for the accumulation of knowledge, and for its organization or transformation into intellectual structure, or intellectual muscle, using Mr. Spencer's phrase. I can think of no educational reform of greater difficulty or of higher utility. A feature of Hubartianism which can not be esteemed too highly is the duty it places on teachers to assist pupils in assimilating the knowledge constituting the circle of thought. The doctrine of apperception finds its justification and its value in the fact that it is an assimilative process, quite distinct from the process of acquisition, though presupposing it. Mental cramming is very like the feeding process which may be observed in railway eating-rooms where travelers feel constrained by the pressure of time, to bolt their food, rather than to eat it in the leisurely way prescribed by dietetics.

The so-called enrichment of our school courses is largely responsible for the evils of cramming. Each ambitious specialist demands a place on the programme for the subject which is the especial object of his regard. Professional zeal is to be commended when hemmed in by competing subjects, but it easily passes beyond proper metes and bounds when it inspires a strong and aggressive personality. We can live on friendly terms with a man who asserts that there is nothing like leather, but we can scarcely abide one who contends that there is nothing but leather. As long as this overcrowding of programmes continues, and there are no signs of a halt appearing, there seems to be no hope of a saner educational régime.

Here is another case in which we may make substantial progress by turning backward.

In his "History of Greece," Curtius makes the following remark:—"The mental culture [of the Athenians] was but plain and simple, yet it took hold of the entire man; and this all the more deeply and thoroughly because the youthful mind was not distracted by a multiplicity of subjects and could therefore more closely devote itself to the mental food and to the materials of culture offered to it." (Vol. II., p. 416.)

Mahaffy, in his *Old Greek Education*, speaks to the same effect as follows:—"Neither was there in old days that multitude of special subjects, totally unconnected with each other or with a liberal education, which now infests our educational establishments, and causes the hurry after tangible results to displace the only true outcome of a higher education—that capacity to think consecutively and clearly, which is to be acquired by studying a logical and thoroughly articulated branch of knowledge for the sake of its accuracy and method." (P. 137.)

The complexity which in these later days has succeeded the old-time simplicity is temperately stated by Mr. Wilson Farrand, Head Master of the Newark Academy, in his article on "The Existing Relations Between School and College":—"It is not enough," he says, "that the child should learn to handle skillfully the tools of all learning—the three R's; his sense of form and his aesthetic nature must be developed by drawing; his hand must be trained by manual work; his musical nature must be awakened by song; he must be brought into harmony with his external environment by means of nature lessons and the study of science; his patriotic impulse must be roused by the study of American history and by flag drills; temperance must be instilled into him by lessons in physiology with special reference to the effect of alcohol on the human system; his imagination must be cultivated by means of acquaintance with Greek and Norse mythology; he should gain some knowledge of the great heroes and events of general history; through the plentiful reading of masterpieces he should acquire a love for and an appreciation of the best literature, while at the same time his mind should be stocked with choice gems of prose and poetry that will be a solace and a comfort to him throughout his later life; it will be well if by displacing a little arithmetic or geography he can gain some knowledge of the elements of Latin or of modern language; in some manner there should be roused in him a love for trees, a respect for birds, an antipathy to cigarettes, and an ambition for clean streets; and somehow, somewhere in this wild chaos, he must learn to spell! All these things, together with sewing, cooking, carpentry, principles of morality, and gymnastic exercise can easily be acquired in the grammar grades, provided only we have good teaching and proper economy of effort. Do you wonder that sometimes teachers in progressive schools confide to us that they fear their pupils are slightly bewildered? Do you wonder that pupils do not gain the habit and the power of concentrated, consecutive work?"

Rousseau declares that we no longer know how to be simple in anything. All reforms consist essentially in a return towards simplicity. How hopelessly complex our courses of study have become! How bewildering it is to think what they are likely to become if prevailing tendencies remain unchecked! We are bound to recollect that times are changed and that we are changed with them. No one in these days would dream of recommending a sheer return to the Seven Liberal Arts; but on this scanty bill of intellectual fare it was easily possible to produce what is almost an impossibility in modern times,—a liberally educated man.

The quotation from Mr. Farrand recalls a scene that occurred in the church of Santa Croce in Florence. This ancient Gothic church is rich in those art treasures of inestimable value which have made Florence "the joy of the whole earth," and each year witnesses throngs of visitors, attracted either by vain curiosity or by a sincere purpose to gain inspiration and spiritual insight through the ministrations of art in its various forms. It goes without saying that for this purpose time and meditation are necessary. As photographers would say, there must be an *exposure*, for a longer or a

shorter period of time, depending on the resources and taste of the visitor. Any attempt to grasp all would result in losing all. In order that some things may be adequately seen many other things must remain unseen.

On the occasion referred to there was an irruption into this church of Holy Cross by a party of American tourists, numbering sixty. It was a "personally conducted" party with a leader of the strenuous order who stood not on the order of his going. I seem still to hear his orders, given in strident tones:—"Come on!" "Hurry up!" "Put up your note books!" etc., etc. Then followed a sort of scurry from tomb to tomb, through aisles and chapels, till the door of exit was reached and the party disappeared to repeat the farce at some other place of note. These countrymen of mine *had done* the church of Santa Croce in just fifteen minutes by actual count. Racing through a cathedral is very like racing through an over-crowded course of study, and one is just as defensible as the other.*

But a pernicious source of undue mental strain remains to be noted,—I mean examinations which are made to involve the fate of students for good or for evil. The evil in this case is often a double one:—the severity of the examination may be inordinate, and the consequences of failure may be a blight on the student's future life. An actual case may best illustrate my meaning: In a school of collegiate grade it was the custom to subject the first-year class to a mid-year examination of such severity that half of its members failed to reach the arbitrary standard set for passing, and so were sent home under the cloud of failure. It is easy to see how by tradition this examination became to each incoming student a terror in prospect. As a matter of fact, the nervous dread of this impending crisis fell as a blight upon the lower ranks of the school, and unfitted even well qualified students for passing this dreadful ordeal with even moderate credit. Naturally enough, when the cause of this nervous disturbance had been removed, the fear of an impending evil continued to affect the school, just as the throbbing of the ocean continues after the storm has passed.

An examination on which so much is made to depend may be as fatal in its way as a Gatling gun. Through this secular abuse of power, is it any

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*Two members of the Rolling Stone Club, of Medina, N. Y., have written a book telling how to "do" Europe on $4 a day. "Florence is a dream," they say. "We came for three days and staid five, and dragged ourselves away unwillingly. Yet it can be done in a day, and we saw it being done in that way more than once. The Baptistery is noted for its beautiful bronze doors. We were standing one day before the pair by Ghiberti, when a fine equipage whirled up. Two exceedingly prosperous looking Americans, with their wives, occupied the seats."

"'These are the doors,' droned the guide on the box seat, 'that Michael Angelo said were good enough for heaven.'

"'All right,' said one of the jovial tourists, looking at his watch, we'll trust his judgment. Let 'em run!'

"And as they were whisked away after just five seconds before one of the most artistic creations in Europe, we saw the man who sat with his back to the driver, nearly dislocate his neck as he twisted around to ask:

"'Who'd you say said that?'

"And the Limited having passed, we resumed our leisurely enjoyment of the masterpieces."—*N. Y. Tribune.*

wonder that in too many cases, students look upon their instructors as their natural enemies whom they may properly circumvent by ruse and fraud? I am far from thinking that the case cited is a common one, but I maintain that the evil *in kind* is frightfully common. The evil consequences of such mental strain are for the most part occult, only the graver consequences coming to the surface; but if an actual inquest could be made, the showing would be a blot on our so-called higher education. It should be remembered that one of the crudest instruments in the hands of teachers is the examination. Its abuses are so common and so flagrant as almost to justify its disuse, and its shortcomings should give pause to those who employ it as a test. It does not bring to the surface the finer qualities of spirit which constitute character, such as faith, hope, charity, but rateher the coarser qualities of mind such as memory, imitation, rote-learning, etc., etc.

A few years ago, in a certain western state, an item to this effect went the rounds of the newspapers: "This has been examination week in our University, and the results attest the high quality of work done by our Professors. In one case, out of a class numbering nearly one hundred, only sixty were passed, the remainder being either conditioned or not passed. We think this is conclusive proof that our University is rapidly coming to the front as an institution for dispensing the higher education." More correctly stated this item would run as follows: "Professor X has taught his large class in his own way, has examined it in his own way, and his work has been so well done that only sixty per cent of his students could stand the test which he applied to them."

THE LEADERSHIP OF THE FEDERAL GOVERNMENT IN PUBLIC EDUCATION.

R. H. JESSE, PRESIDENT OF THE UNIVERSITY OF MISSOURI.

Few, even among intelligent people, realize to how great an extent the general Government has led the States and the people of our country in public education. We are prone to think of this progressive state, or this enlightened man, or that seat of learning as leading our people aright, forgetting that oftentimes the general Government has whirled onward in education, states, with their leaders and their seats of learning.

In 1787 the Continental Congress, shortly before it passed out of American history, passed an Ordinance for the government of the Northwest Territory, which means for that territory which lies west of the Allegheny Mountains, east of the Mississippi River, north of the Ohio, and south of Canada. This document contained, in Article III, this remarkable sentence: "Religion, morality and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged." This policy was confined to the Northwest Territory, but it has since been extended by the general Government to all the

territory west of the Allegheny Mountains, excepting only Texas and West Virginia. This sentence, indeed, has proved to be the Magna Charta of public education in the United States. This I shall point out later. In 1789 the Continental Congress had passed away, the Constitution had been adopted, Washington had taken his seat as President and the first Congress was holding its first session. Early in the session an amendment to the Ordinance of 1787 was adopted. This amendment was intended to bring the Ordinance into harmony with the new form of government and thereby to perpetuate it. Therefore, the amendment was practically a re-enactment of the Ordinance of 1787. This amendment and re-enactment was signed by George Washington. We are glad to bring into connection with this immortal Ordinance the name of him whom we proudly call "Father of our Country." Almost immediately after the passage of the Ordinance of 1789 the general Government made with the Ohio Company a contract whereby a large territory in that commonwealth should be open to settlement, upon certain conditions. One of these conditions was that the sixteenth section in each township should be reserved for the public schools and that two entire townships, each consisting of thirty-six sections, should be reserved for the endowment of a "Seminary of Learning," which, being interpreted into the language of today, would mean, a Seminary of Higher Learning, and which became a State University. These conditions were imposed in accordance with that sentence in the Ordinance of 1787 which declares that throughout the Northwest Territory, "Schools and the means of education shall forever be encouraged." This sentence is the Magna Charta of the public school system, and in fulfillment of its provisions, these conditions were laid upon the early settlers of Ohio. The same conditions were afterwards laid upon other states formed out of the Northwest Territory, and they were, at a still later time, extended to the states carved out of the Northwest Territory, and they were, at a still later time, extended to the Louisiana Purchase and to other states otherwise acquired. Whenever a territory west of the Allegheny Mountains knocked upon the doors of Congress asking for admission to the sisterhood of states, certain conditions were imposed upon the territory by the general Government. If the territory, by popular vote, pledged itself to carry out these conditions, it was admitted to the Union, but otherwise it was not admitted. One of these conditions was that the sixteenth section of land in each township should be reserved for public schools, and another was that, in general, two townships, of thirty-six sections each, should be reserved for the endowment of a Seminary of Learning, which, in every case, was interpreted to mean a State University. In pursuance of the educational policy contained in the Ordinance of 1787, the general Government required each territory in the country west of the Allegheny Mountains to take a certain stand in behalf of public education, elementary and higher, before it should be admitted to the Union. The people of these early territories do not seem to have been generally zealous in behalf of education. They accepted the conditions imposed by the general Government because without such acceptance they could not enter the Union;

but some of them long neglected their universities so far as the conditions imposed by the general Government permitted. For nearly thirty years the Legislature of Michigan did not give to the University at Ann Arbor a single dollar, but left it to maintain itself wholly upon the proceeds of the Federal lands and upon tuition fees. In Missouri the Legislature took no steps to found the University until nearly twenty years after the state had been admitted to the Union. When the University was finally established, it was suffered to starve for twenty-seven years without the gift of a cent from the State Treasury. The first appropriation was $10,000 for the space of two years. Then came appropriations, slowly increasing, but it was not until the University was fifty-one years old that the maternal affection of the state towards its greatest institution began to be manifested in really worthy degree. It would seem that in many cases the Federal Government led, rather unwillingly, states, so far as higher learning, at least, is concerned. Texas and West Virginia are the only states west of the Allegheny Mountains that have been admitted to the Union without conditions committing them to a public school system from the elementary forms to the university. Texas was admitted in the troublous times attendant upon the Mexican War and West Virginia was torn from the old dominions amid the horrors of civil war and as a stroke of war policy. In view of these facts, who can deny the statement that from the crest of the Allegheny Mountains to the shores of the Pacific Ocean, the Federal Government has been leading the states and their people, sometimes rather against their will, into wise policies in public education.

No account of education by the state, or by the United States, would be complete without some account of the work of Thomas Jefferson. His services as author of the Declaration of Independence, as statesman, diplomat, cabinet minister, and President have obscured the services which Jefferson rendered to education. In 1779, three years after he wrote the Declaration of Independence, Jefferson introduced into the House of Burgesses in Virginia a bill establishing in that commonwealth a comprehensive system of public schools. His bill provided for elementary schools, secondary schools, and at the head of all such a State University as has not yet been realized in our country. The bill attracted great attention at the time, but it should not seem strange that, amid the sorrows of the Revolutionary War, it came to naught. From 1779 until his death in 1826, Jefferson was dominated by a passion for freedom through republican institutions, and by a passion for public schools at public expense. For forty-seven years, with tongue and pen, in public and in private, he pleaded the cause of public education without rest or abatement. When we remember his exalted position, his wide acquaintance with public men, his enormous correspondence, his dominating passions, we can gather an adequate idea of how great an influence he wielded in behalf of education. His name may not be connected with any great act in behalf of schools. Indeed, his ideas of the Constitution rather prevented him from advocating education at national expense, but for nearly a half century he was the foremost advocate in all our land for state aid for public education from the elementary forms through the ideal

State University. It is impossible to exaggerate the influence which he exerted in fastening in the minds of the people of our entire country the idea that public money ought to be used liberally by the states for public education. The last years of his life were spent in a prolonged struggle to induce Virginia to adopt his plan of public education. For reasons that pass our comprehension, Virginia refused to establish elementary or high schools. It did finally establish a State University but it was only a tithe of that University of which Jefferson had fondly dreamed.

In 1858 Justin S. Morrill of Vermont introduced into the Senate of the United States a bill establishing agricultural colleges. The measure was passed by a small majority but it was vetoed by President Buchanan, who showed genius for doing unfortunate things. In 1862, amid the horrors of civil strife, Senator Morrill introduced his bill again with slight modifications. Again it was passed by Congress and was signed by Abraham Lincoln. We are glad to connect this wise measure in behalf of higher education with the name of him whom we may justly call the second Father of his Country, and the Author of the Second Declaration of American Independence. The Morrill Act offered 30,000 acres of land belonging to the general Government to each state for each congressman and senator that it had at the time when the Act was passed. Certain conditions were prescribed to which each state had to conform in order to inherit the federal bounty. The Government made gifts to the state in behalf of higher public education with one hand and with the other hand led these states into a certain attitude before they became recipients of the gifts. These institutions were intended to be colleges in the true sense of the term. In standards of admission, in standards of graduation, in courses of instruction, they were to be real colleges. They were at liberty to teach anything, even including the classic languages, that was taught in other colleges, but it was provided that agriculture and the mechanic arts should have a prominent place in the curriculum. Some states were wise enough to place these colleges in their universities, but some were unwise enough to establish them on separate foundations. The colleges of agriculture that have been founded in universities are destined, I dare affirm, to far excel those that rest on separate foundations; while the State Universities that are fortunate enough to have these colleges in their midst, are destined to excel the other State Universities. The conjunction is full of blessing to the college and also to the University.

In 1887, just a hundred years after the passage of the great Northwest Ordinance, Congress passed an Act establishing Agricultural Experiment Stations in connection with the Colleges of Agriculture and it endowed these Stations in the sum of $15,000 annually. The original grants on which rest the State Universities west of the Allegheny Mountains were grants of land and when each territory had bound itself to comply with the conditions imposed by the general Government, the gift became irrevocable. The same was true of the land grant of 1862. But the Act of 1887 gave grants of money to be appropriated by Congress at each regular session and

the stations were placed under the supervision of certain officers at Washington. It was made the duty of these stations to make investigations into the arts and sciences connected with agriculture and to spread among the people by publications and otherwise the results of these investigations and such accumulations of useful knowledge as the stations might be able to gather. At first glance the field of investigation seems to be narrow, but, in reality, it was very wide. It includes research in Agronomy, Animal Husbandry, Dairy Husbandry, Veterinary Surgery, Horticulture, Entomology, Botany, and so much of Physics, Chemistry and Bacteriology as are involved in problems connected with the soil, with plant life and with animal life. But much more is involved in this remarkable Act than appears on the surface. Our forefathers had worked their way slowly to the idea that public money might justly be used for the education of the young, provided they were gathered together in elementary or secondary schools, or in colleges or universities.

But the Act of 1887 declares that public money may justly be used for research. This was an immense stride forward. Our forefathers came slowly to the idea that public money might justly be used for the education of the young provided that they were assembled in schools, colleges, or universities. But the Act of 1887 declares that the results of research in the Stations and the accumulations of useful knowledge pertaining to agriculture may be spread among the people broadcast at public expense and the information is to be given to men and to women and to the young, the middle aged and the old, not collected in schools, colleges, or universities, but at their homes. The knowledge is to be spread by publications, lectures, or by any other proper method. The Federal Government in this Act endowed research and also University Extension. So anxious was the Government to facilitate the spread of information among the people that the publications of these Stations are carried in the mails free of postage. Our forefathers justified the education of the young at public expense on the ground that an intelligent citizenship was necessary for the maintenance of republican institutions. They seem to have feared that an uneducated rabble might rise some day in this country as it did in France to tear to tatters the fabric of Government. Their policy was based on selfishness although the selfishness was not lacking in enlightenment. In the Act of 1887 the Government came much nearer than it had ever done to a policy of altruism in public education. "We must educate," said our fathers, "to protect our institutions." "We must educate," say the men of today, "because it is as much the function of a Government to educate its people as it is its function to rule them and to protect them." "We must educate," say the men of today, "not only because of the preciousness of our institutions but also because of the preciousness of the individual soul." While the Act of 1887 does not include this modern altruistic view as stated above, it comes far closer to it than any other Act of the Federal Government has hitherto come.

The endowment of 1887 was not irrevocable. Therefore, as often as Congress meets in regular session and passes appropriations for the Experi-

ment Stations, it thereby sets its seal to the truth of all the doctrines in the original Act, which was passed not by one Congress in a spasm of exalted virtue, but has practically been ratified by every Congress since 1887.

The states at first accepted the Federal bounty without doing anything themselves. The general Government had been leading faster than they were prepared to follow. But slowly first one and then another began to make appropriations out of state funds for their Experiment Stations until at the present time there is probably not a commonwealth in the Union that does not add out of its treasury to the amount received by its Station from the general Government. Therefore, as often as each Legislature meets it sets the seal of the State, unconsciously perhaps, to the truth of all the doctrines contained in the Act of 1887.

A Missourian may be pardoned for saying that the Act of 1887 was introduced by William H. Hatch, who for many years represented in Congress the First Congressional District of Missouri. The measure is now called unanimously "The Hatch Act."

In 1890 Senator Morrill, the father of the Colleges of Agriculture, introduced into Congress an Act increasing their appropriations in a sum of money which was to grow annually until it became $25,000 a year. This is generally known as the "Second Morrill Act." It was signed by Benjamin Harrison.

Does it seem to be an accident, or more, that all the steps forward of the Federal Government in its leadership of the States in public education were taken under the administrations of great Presidents? Is it an accident or more that none of these measures were passed under the administrations of Martin Van Buren, William Henry Harrison, James K. Polk, Millard Fillmore, Franklin Pierce, James Buchanan, Rutherford B. Hayes, and so on; but they were passed under Washington, Lincoln, Grover Cleveland, and Benjamin Harrison? And some would fain hope that yet another is to be passed under that magnificent man and hero, Theodore Roosevelt. It is a goodly fellowship of Presidents.

Harvard points with pride to her pious founder and so likewise Yale and Princeton and the Hopkins and Tulane and the University of Chicago. Some of these founders, peradventure, were not very pious but the term is still applied to them and probably justly. Pious they have been, certainly, in so far as they have founded institutions of learning. The State Universities west of the Allegheny Mountains can point with pride, as to a pious founder, to the Federal Government. They have been founded by their States and are proud of that fact, but they do not forget that the State was originally guided by the Government of the United States. In a certain sense they can claim as founders Washington, Jefferson, Lincoln, Cleveland, and Benjamin Harrison. These universities may lift up their heads in just pride for their lineage also has been illustrious. They beyond all universities in America ought to be nurseries of civic virtue. In their midst should burn like a vestal flame, unquenched and unquenchable, love of state and love of our common country.

PHYSICS SECTION

A SIMPLE FORM OF MACH'S WAVE APPARATUS.

PROFESSOR E. A. STRONG, MICHIGAN STATE NORMAL COLLEGE.

The simplification of the old form of Mach's Apparatus, a piece often made or imported by schools and colleges, consists in three modifications which only slightly impair the efficiency of the apparatus, while they render it cheaper and more convenient.

Instead of the usual rigid supports, the collapsible parallel bars may be mounted on ordinary laboratory standards by means of clamps. The apparatus may then be rolled up and treated like a map or chart, thus saving space,—a most valuable asset in a laboratory.

In order to release the balls in the two representations of reflected or stationary waves, electro-magnets may well replace the cumbrous lever, worked by the foot, seen in the original piece. Better still, a simple gravity release may be used.

Also the same piece that is used to pull off the longitudinal progressive wave may be used to pull off the transverse progressive wave.

The piece was exhibited and put into action.

Among the many methods employed to show wave forms, the speaker preferred some of the stroboscopic methods, as Quincke's.

THE RELATION OF MATHEMATICS TO PHYSICS IN THE HIGH SCHOOL.

DR. H. M. RANDALL, UNIVERSITY OF MICHIGAN.

At the present time a widespread interest has been aroused in mathematics, and some very radical changes in the methods of teaching it have been suggested. As the subject of physics is involved in the proposed changes, it seems but fitting that this conference, the representative body of physics teachers of this state, should undertake to do its part towards finding a solution for the problems thus called forth. I have been asked "to start the ball rolling," and feel I can do so in no better manner than by stating as briefly as possible, first, what seems to be the prevailing sentiment regarding mathematics teaching; second, the general ideas of the proposed changes. My information upon the subject has been derived largely from articles which have appeared during the last two or three years in various mathematical, scientfic, and educational publications. At the best, then, what follows can be regarded only as a summary of the ideas of the writers of

these articles, a majority of whom, it may be worth while noting, are mathematics teachers.

There is a large class of persons, including in their number engineers, physicists, and chemists, who want their mathematical knowledge to be strictly usable. It is the consensus of opinion among these men that it is not usable to a sufficient degree, and they demand that the mathematics taught them be less formal and more practical, and, moreover, there is a growing tendency to the admission that this position is a sound one, that knowledge, so taught that it can be used, must necessarily be more valuable than when taught otherwise.

Physics teachers as a class, moreover, have a grievance arising from the attitude which pupils assume to all things mathematical in physics. While physical ideas are being developed, a class may be all interest, but when the time comes to express those ideas mathematically, the situation changes. The more conscientious prepare to receive the bitter which always accompanies the sweet, the less conscientious ones, while present in body, are plainly absent in mind. This attitude is indicative of the dislike which the pupil has acquired for mathematics during his training in it, and of his belief in its uselessness. It is a severe criticism of the present method of teaching the subject. If physics teachers have anything to ask of mathematics teachers, it is that they endeavor to change this attitude of the pupil to the reception of mathematical ideas. As one can be interested in those things only which one can understand and do, the above situation seems to demand also less formal and more practical mathematics.

Now as to the general ideas of the proposed changes. Great emphasis has been placed on the value of mathematics as a means of mental discipline. So much so possibly that it has often become the end. Prof. Klein of Göttengen has called attention to the fact that another chief value is this: "To make the conviction grow that correct thought on the foundation of correct premises gives mastery over the external world. To do this, attention must be directed to the external world from the beginning." This is the key to the proposed changes. A quotation from a report "On the Teaching of High School Mathematics," read before the Mathematics Section of the Chicago and Cook County High School Teachers' Association, states the idea very plainly. "In present discussions of the possibility of improving the teaching of mathematics, the vital point seems to be that there should be, first, a concrete problem and then its expression in mathematical language, rather than first instruction in the language and then its application to the expression of problems. By problems we mean some real question in the world of senses, not an example from a book. If this is right, the equation has no right for existence till there is first a truth for it to tell. The more the truth told appears to the pupil as worth telling the better." If the pupil then has had experiences which are capable of being expressed mathematically, use them, if not, give him such experiences. As an illustration of the latter case, a spring balance, when the stretches due to various weights are noted, tells the fact that the stretch is always a certain number of times

larger than the weight, say 5, this truth may be briefly expressed by the equation $s = 5w$. Another balance may give $s = 8w$. Other balances would yield similar results, and a second important truth appears, *i. e.*, all balances have similar equations. This may be told by $s = cw$, a general equation, which can be applied to any balance as soon as c is experimentally determined.

Use is to be made of a pupil's intuition and experience. If his common sense tells him that a certain mathematical idea is true, to compel him to demonstrate it before his logical powers are sufficiently developed to make him feel the need of a proof, is to put him often in a state of confusion, as he can see no reason for proving something which is selfevident. On the other hand, if an experimental test of his ideas shows their correctness, he gains confidence in his judgments. So experimental proof may often be substituted for formal demonstrations, and even the conclusions reached by such demonstrations may well be tested experimentally.

If the pupil's mathematical ideas, wherever possible, are thus derived directly from his experiences, will he not regard the subject as a most practical one? Will he not naturally wonder, when he has acquired ideas by observation, if they may not be mathematically expressed? In short, will he not have that attitude to the reception of mathematical ideas which physics teachers would wish him to have?

To furnish these concrete ideas upon which the mathematical ones are to be built, there will have to be a mathematical laboratory. This laboratory, if one judges from the lists of necessary apparatus, might well be mistaken for a physical laboratory. This means that physics is regarded as the subject best suited to give the needed experience, and that mathematics and physics are to be closely correlated or possibly more. It may mean that neither mathematics nor physics, as such, is to be taught, but in their place a single subject which is the result of thoroughly amalgamating the two. That such a scheme could not possibly succeed if applied under present conditions is evident to no one more clearly than to those who are proposing it. Its present practicability is not the question, but rather, would such a training give the pupil a mathematical and physical knowledge which is usable, and would he be filled with a desire to use it? If this question is answered in the affirmative we come to a most practical question of our subject: To what extent could these ideas be put into operation at the present time? In the first place, teachers with a sufficient knowledge of both mathematics and physics for the successful correlation of the two subjects in the manner indicated are very few in number, and progress must of necessity be slow until such teachers are developed. However, if the present situation be accepted as it is, it is possible to make modest attempts in the direction indicated. Such attempts are being tried at various schools, notably at Lincoln, Neb., the Bradley Polytechnic Institute at Peoria, Ill., and at a number of schools in and about Chicago. The general plan of operation seems to be to have in the first year of high school work a course in elementary science, in which the physical laws with which the pupil comes in daily

contact are explained by aid of experiments. Upon the concrete ideas thus obtained, the algebra and geometry taught together are founded as much as possible. This work is continued during the second year with the introduction of elementary ideas of trigonometry. The results are said to be a greater thoroughness and insight into the subject of algebra and geometry. The pupil comes to the subject of physics proper in the third year with definite, usable ideas in mathematics, which include those of positive and negative quantities, ratio both direct and inverse, together with considerable skill in the manipulation of such equations as are ordinarily found in physics.

AN INDUCTION COIL INTERRUPTER FOR CURRENTS OF HIGH VOLTAGE.

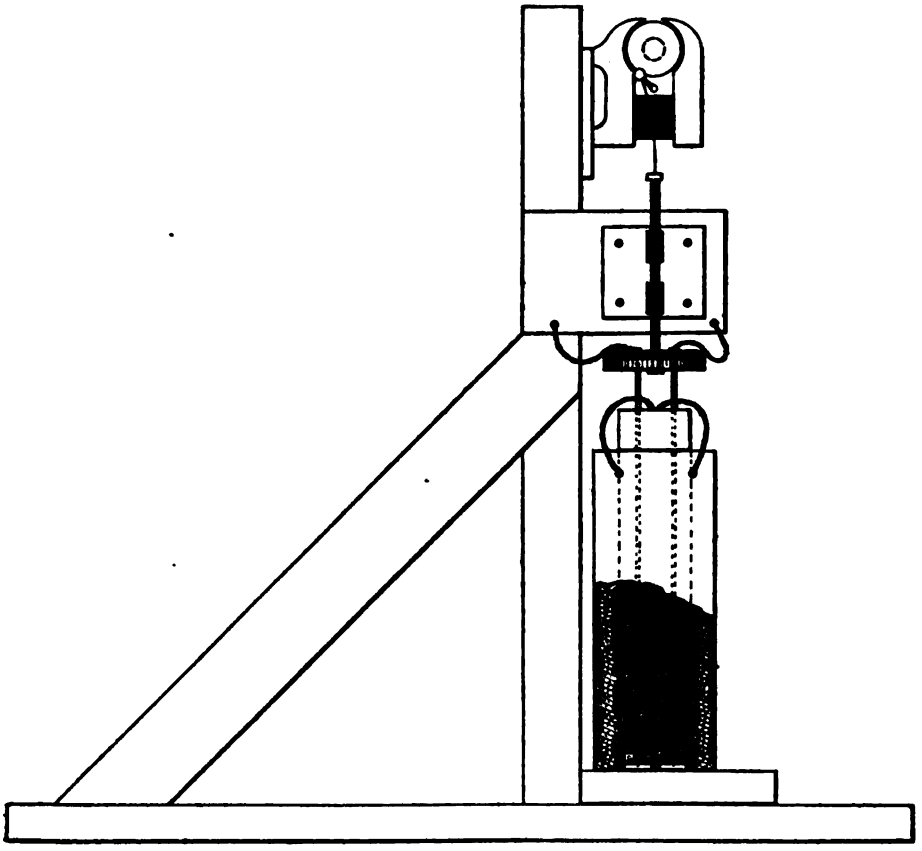
PROFESSOR G. E. MARSH, ADRIAN COLLEGE.

In induction coil work the ordinary interrupters cease to be of service if the potential difference across the break, when no current is flowing in the primary coil, is high enough to maintain an arc between the contacts, namely, about 40 volts. In the case of a coil energized with current derived from a 500 volt circuit, the drop in potential at the break is many times this voltage if the current-strength is of the requisite magnitude.

The apparatus about to be described was devised to permit the operation of an induction coil on a current accompanied by a potential beyond the range of the ordinary interrupters. The principle involved is the following: A mechanically actuated interrupter of the mercury-in-alcohol type, possessing multiple contacts or plungers, electrically connected in series, and having a large and rapid motion of translation. In detail, the interrupter consists of four glass tubes 5-8 inch in diameter and 8 inches long, placed in a square, zinc-lined box, the dimensions of which are such as to hold the tubes securely in position. The unusual length of the non-conducting liquid is to provide a column of oil or alcohol so deep that its inertia is a factor in resisting and preventing the formation of bubbles of vaporized oil at the moment of breaking the circuit, and which are essential to the existence of the arc. The lower end of each tube is closed by a cork and a layer of plaster of paris. Electrical connection is made with the stratum of mercury in each tube by means of a wire carried down through the central space between the tubes, and terminating in a flat spiral resting on the layer of plaster of paris.

Attached to the lower end of a brass rod, constrained to move vertically by means of suitable guides, is a disc of wood, and from this are supported the four plungers. In order that the plungers may be as rigid as possible, and yet free from any undue weight, they are made of copper tubing, ⅛ inch in diameter, the lower ends of which are provided with sharply-pointed copper tips. Electrical connection is made with the plungers through flexible

conducting cords. The zinc lining extends above the tubes, and kerosene oil, which is used in preference to alcohol for obvious reasons, fills not only the tubes but the space about them. The motor has a pinion on the armature shaft which meshes with a second gear on the crank shaft. The gearing is on the farther side of the motor and is not shown in the illustration. In order to simplify the mechanical construction, a piece of spring brass was



used to connect the sleeve carried on the crank with the rod supporting the plungers. This rather novel use of spring brass in lieu of the ordinary connecting rod introduces no especial resistance, and answers satisfactorily.

The breaks occur in series: that is, the mercury of tube No. 1, say, is electrically connected to plunger No. 2, and the mercury of this tube is connected to plunger No. 3, and so on. Thus there are produced simultaneously four arcs, and, in order that they may be started at the same instant, it is clearly necessary that the heighth of the mercury in each tube shall be the same, supposing, of course, that the plungers are of equal length. If one of the plungers fails to emerge from the mercury at the same instant the

others begin to leave the surfaces, the delinquency of the first increases the intensity of the arcs at each of the other three, and by prolonging the dying away of the current lessens the efficacy of the interruption. A condenser is shunted around each of the four places at which arcing takes place.

The motor alone is capable of running at a very high speed, though, with the load resulting from the weight of the moving parts, the number of interruptions is not greater than 250 or 300 per minute. The success with which the interruptions are accomplished is such that it is perfectly possible to join the coil and interrupter in series with a suitable rheostat, and obtain a satisfactory spark-length when the current is taken directly from a trolly line and has strength of 15 amperes. A shunt of comparatively high resistance connected around the coil and interrupter is, however, an addition that improves the performance of the induction coil.

By increasing the number of plungers or the rapidity of operation, or both, the fall of the current can be made as brief as required, and thus adapt the apparatus to the successful interruption of currents of any voltage. In the case of four-plunger interrupter such as described, and making three hundred breaks a minute, the time consumed in the dying away of the current is not greater than one-thirtieth of a second.

NEW USES OF THE MICROMETER SCREW.

PROFESSOR N. F. SMITH, OLIVET COLLEGE.

So many quantitative experiments in physics involve a measurement of length, that accurate methods of measuring this quantity have always claimed a large share of attention. For elementary students the micrometer screw is probably at once the simplest and the most accurate method available. Hence new uses of this instrument are constantly suggesting themselves. The following applications have been found useful:

1. *In the Determination of Young's Modulus by Stretching.*—A wire about four or five meters long is rigidly fastened to a solid wall by a heavy hook at one end. The free end passes over a pulley and carries the load. Near the free end an index of wood or metal is clamped to the wire and projects between the jaws of a micrometer caliper clamped in a rigid support. By this method the elongation of the wire can easily be measured with considerable precision.

2. *In Determining the Coefficient of Linear Expansion of a Metal.*—Many laboratories are supplied with a linear expansion apparatus in which a lever is used to magnify the amount of expansion. Considerable inaccuracy arises from the difficulty of measuring exactly the length of the short arm of the lever. This troublesome measurement may be avoided by

inserting between the end of the bar and the short arm of the lever a thin piece of metal whose thickness is approximately equal to the amount of expansion of the bar. The motion of the long arm of the lever can then be observed and the thickness of the metal measured with the micrometer caliper. A simple proportion then gives the expansion of the bar. The same method is of course applicable to other cases where the lever is used as a magnifying device for measuring a small distance, as in problems on the elasticity of bending, etc.

3. The third experiment to which I shall call attention is one which can be elaborated almost indefinitely according to the advancement and ability of the student. It introduces him to a most fascinating field of experiment to which but little attention is ordinarily given in a laboratory course, viz., the passage of electricity through gases. The particular experiment to be described has for its object the determination of the spark length in air at atmospheric pressure, which requires the same potential difference as a spark of constant length at various lower pressures. For this purpose a receiver, provided with an adjustable spark gap, is connected with the air pump, and the electrodes are set at a distance of two or three centimeters. One of the ordinary terminals of an induction machine is removed, and in its place is mounted a ball on the end of a micrometer screw in such a way that the distance between the two terminals can be readily measured. The terminals of the machine are then connected with the electrodes of the receiver and the air exhausted. The spark gap on the machine is then adjusted till the discharge passes with equal readiness between either pair of terminals. A pressure gauge connected with the receiver gives the degree of exhaustion. A small amount of air is admitted, increasing the pressure, and the adjustments are repeated.

Some uncertainty exists in making the settings because it is difficult to judge when the spark passes with equal readiness by either path. The condition of the electrodes and of the air between them have an important influence. After the discharge has once commenced to travel by a particular path, it appears to adhere to that path in preferance to the other even when the distance is somewhat increased. Nevertheless, by exercising care and taking the mean of several settings for each pressure, a very characteristic curve may be obtained. Since the length of spark is not proportional to the potential difference, the curve does not give directly the relation between electromotive force and pressure as might be desired.

An interesting variation of the experiment consists in keeping the spark length in air fixed at some constant value, such as half a centimeter, and varying the length of the gap in the receiver with each change of pressure until the two gaps are equivalent. A scale graduated directly on the rod of the movable electrode serves to give the spark length in the receiver. In this case the potential difference is kept constant, and we have the relation between spark length and pressure. The same method would serve to compare the dielectric strength of different gases.

THE USE OF THE WIRE MICROMETER IN MEASURING EXPANSION.

H. N. CHUTE, ANN ARBOR, MICH.

In the problem of determining the co-efficient of linear expansion, the chief difficulty encountered is that of measuring accurately the expansion of the rod or tube. The wire micrometer offers a very simple solution of this problem. Instead of a rod, use a tube, supported horizontally on two blocks fastened to a board or clamped firmly to the experimental table. These blocks are placed near the ends of the tube. The tube is held in place by a pin passing vertically through it near one end. This pin projects a few centimeters above the tube. The other end of the tube is kept in place by a staple. The tube is now free to expand in one direction. A second pin is soldered vertically to the tube and near the free end and the length of the tube is taken as the distance between the two pins. The wire micrometer is clamped over the free end of the tube so that the face of the screw can be brought against the outer face of the pin and the reading taken. The head is now given two or more turns backward, and steam passed through the tube till it is thoroughly heated. The micrometer head is then turned till contact is secured as shown by the slipping of the head, and the reading again taken. The difference of these readings gives the expansion. The temperatures are obtained in the usual way.

AN EXPERIMENT IN INTERFERENCE OF LIGHT.

PROFESSOR N. F. SMITH, OLIVET COLLEGE.

A simple interference apparatus has been suggested by Dr. Millikan, of the University of Chicago, which, so far as I am aware, has not been described publicly. Its simplicity renders it suitable to place in the hands of elementary students. Two pieces of plane parallel glass about three centimeters long are mounted in openings near the ends of two straight sticks from forty to fifty centimeters in length. The sticks are hinged together like a pair of tongs and the pieces of glass adjusted to accurate parallelism when the "tongs" are closed. The angle between the plates can be adjusted and the extent of opening measured by a micrometer screw placed near the open end of the "tongs."

When the plates are set at an exceedingly small angle and viewed by monochromatic light, interference fringes parallel to the hinge are distinctly visible.

If w is the width of one fringe, α the angle between the plates, and λ the wave-length, then evidently

$$\alpha = \frac{\frac{1}{2}\lambda}{w}.$$

If δ is the opening of the tongs, and l the distance from hinge to micrometer screw, then we also have

$$\alpha = \frac{\delta}{l}$$

$$\text{Hence } \frac{\delta}{l} = \frac{\frac{1}{2}\lambda}{w}$$

Since all these quantities except λ can be directly measured, we have a method for determining the wave length of light. The method is not one of great accuracy, but it appeals to the student strongly because of its simplicity. If it is found difficult to render the plates accurately parallel, we may make two settings giving fringes of different widths, and then determine the difference in the extent of opening.

THE SLABY ARCO SYSTEM OF WIRELESS TELEGRAPHY.

L. G. HOLBROOK, MICHIGAN AGRICULTURAL COLLEGE.

The three leading systems of wireless telegraphy in use at the present time are the Marconi system, owned by the Wireless Telegraph Company, London; the Braun system, owned by Siemens & Halske, of Berlin; and the Slaby Arco system, owned by the Allegemeine Elektricitäts-Gesellschaft, of Berlin. The principles upon which different systems are based are very much the same. The difference lies in minor points and details of more or less importance in perfecting the system, making it more effective and reliable.

The system devised by Slaby and Arco is the system adopted officially by the German government, and is used by the German navy on all their battleships, cruisers, torpedo boats, naval stations, etc. Also over a hundred stations have been set up on land at various places, making a complete system for military operations.

The apparatus consists of earthed transmitting and receiving antenna and direct coupling at the transmitting and receiving circuits. The sparking circuit is connected direct to the transmitting antenna and the earth. The exact influence of earthing has not as yet been clearly determined, but experiment has shown the desirability of earth connections. It establishes the

nodal points of the pressure oscillations and obviates the possibility of dangerous pressures for the operator.

The transmitting circuit consists of:—

1. Motor current circuit: Source of supply, switch, motor, regulating resistance.

2. Make-and-break current circuit: Source of supply, switch, primary of the inductor, turbine interrupter, Morse key. The primary condenser is in parallel with the interrupter.

3. Inductor high-tension circuit: Secondary winding of induction coil, spark gap, capacity (consisting of Leyden jars), exciting coil.

The receiving circuit consists of:—

1. Coherer current circuit: Coherer, syntonising coil, coherer element, relay windings, hammer and junction. A condenser is in parallel with the syntonising coil and the coherer.

2. Battery current circuit: When the relay armature has closed contact, the parallel coupling of the hammer electro magnet, of the Morse recorder, and of the polarizing cells is made through the battery.

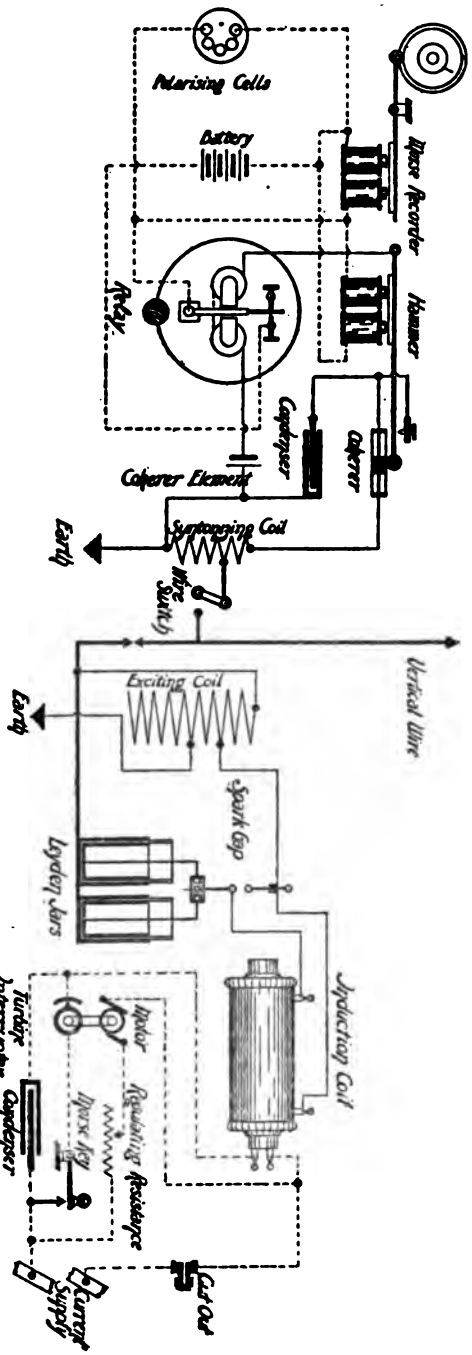
In the transmitting circuit either alternating or direct current is used for the source of supply.

For the make-and-break, the so-called turbine interrupter, designed by the German Electric Company, is found most successful. It contains a metal tube bent at right angles, the lower part dipping in mercury, and its horizontal arm covered with alcohol. The lower part of the tube is in the shape of a turbine wheel, so that when the tube is revolved by means of a small electric motor, the mercury is drawn up the tube and is discharged as a heavy jet from the horizontal arm of the tube. The mercury jet hits upon a metal ring made with a segment and placed concentric to the shaft, and thus makes and breaks the circuit. The mercury bath is connected to one main of the supply and the metal ring to the primary of the induction coil.

This type of interrupter is superior to either the hammer or mercury type of interrupter, which depend upon an electro magnet for their action. These under the most favorable conditions will not give more than forty makes-and-breaks per second. They are not adapted for rapid movement with large currents, and so can not be used for long-distance work. The turbine interrupter also has advantages over the wehnelt type. It is more continuous and more capable of standing rough usage. For ordinary work, however, the wehnelt interrupters are very desirable. They require no motor or condenser, and give from 260 to 2,000 makes-and-breaks per second.

In the receiving circuit the coherer is of special importance. The Marconi coherer is found most reliable. It consists of a glass tube in which is placed nickel and silver filings between two metal conductors about an eighth of an inch apart. The air is withdrawn from the tube, and the tube is sealed. Decoherence is made by means of a hammer electro magnet.

For anything but short distance work, a very sensitive relay is necessary. Extreme care is taken in construction to reduce friction to the least possible



RECEIVING STATION.

SENDING STATION.

minimum, and design the parts so as to attain the highest sensibility. The best relays are sensitive to the current of one ordinary dry cell acting through a resistance of 150,000 ohms.

One of the special features of the Slaby-Arco system is the tuning or syntonising of the receiving with the transmitting circuit. It is shown mathematically and confirmed by experiment that the total length of an oscillating wire correspond to half the wave-length of oscillations; each half of the wire or antenna is the fourth of a wave-length. Each wire excited by a sparking circuit has certain defined oscillations to which the electric waves it sends out into space correspond. These waves set up oscillations in the receiving antenna by induction. This receiving wire, from its size and length, is suited to a given kind of oscillation. If this be the same as that of the transmitting wire, it responds much more readily. The more complete the tuning the more complete the action. The tuning is accomplished by means of syntonising coils of wire and condensers. If the tuning is very accurate, multiple telegraphy from the same receiving antenna is possible, each system being tuned to its own transmitting circuit. Slaby was the first to give publicity to this form of multiple telegraphy. In December, 1900, he received two messages simultaneously from one common antenna. The wave-length of the first system was 640 m., distance 9.3 mi.; the second 240 m., distance 2.5 mi. A simultaneous recording of seventy-two words per minute was received.

For long-distance telegraphy Count Arco has devised a portable syntonning coil, by means of which perfect syntonism can be obtained without effecting other relations.

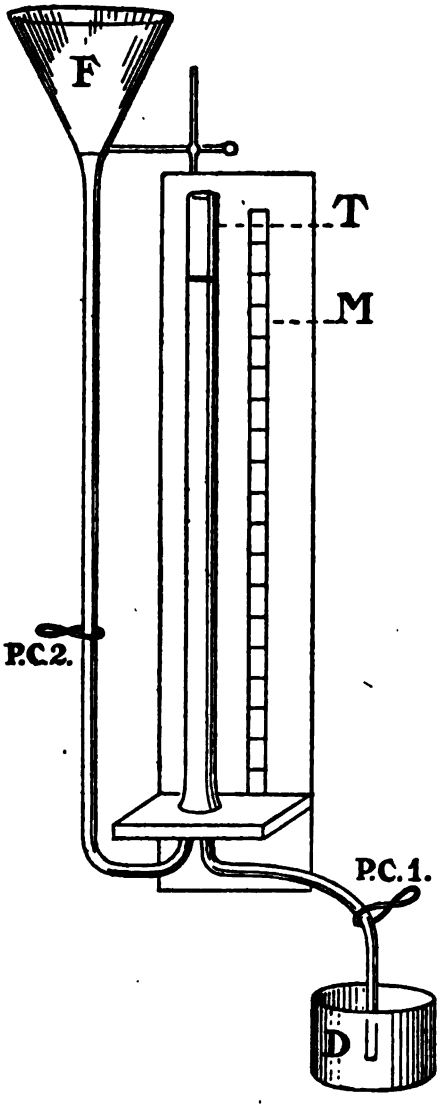
Although tuning will not prevent entirely interference by other systems, it is as yet the principal means of obtaining non-interference in wireless telegraphy.

A DEVICE FOR REGULATING LENGTH OF AIR COLUMN IN A RESONATOR.

J. E. FOX, THREE RIVERS.

The apparatus ordinarily used consists of an assemblage of parts similar to the one in the drawing, the length of air column being varied by raising or lowering the reservoir. I place the water supply stationary, above the tube (t), which is closed at bottom with a double perforated rubber stopper, through which pass two tubes of glass or brass, one of which is connected to funnel (f) with rubber tubing, the other to dish for holding water. Both tubes are closed with pinch-cocks marked p. c. in drawing.

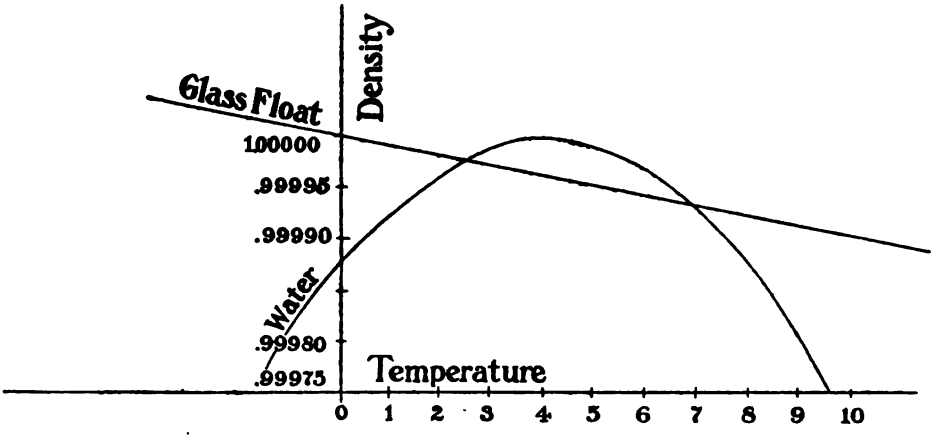
The operator sits in front of apparatus with (p. c. 2) in left hand, and (p. c. 1) in right, and eye in line with the water level. He thus has perfect control of the column through the agency of the pinch-cock. Occasionally the water may be poured from the dish to the funnel.



AN EXPERIMENT TO ILLUSTRATE THE MAXIMUM DENSITY OF WATER.

CHAS. W. BURROWS, DETROIT CENTRAL HIGH SCHOOL.

This experiment was suggested by Thos. Preston ten years ago but only recently has the suggestion been acted upon. The essential part of the experiment is a glass float so adjusted as to be but slightly heavier than water at 0° C. In this illustration today I am using three floats of slightly different densities. The curve of density and temperature tells the story of what happens.



Beginning at 0° C the glass is heavier and sinks but as the water warms the water grows heavier and pushes the float to the surface only to allow it to sink again after the point of maximum density is passed. Owing to the slight difference in density the floats do not rise at the same temperature. The following data are suggestive. The temperature is the temperature of the middle of the water:

Float	Rising		Sinking	
	Top	Bottom	Bottom	Top
Small	0	1	10	12
Medium	1.3	2.3	8.8	10
Large	3	4	6	8

If we try to get the point of maximum density from this table, we find it at about 5° C. This is the result obtained by Depretz in 1840 by means of the water thermometer. The true maximum can be obtained only by a correction due to the expansion of the glass. However, the experiment illustrates very forcibly the fact that there is a point of maximum density.

ENGLISH SECTION

THE VALUE OF LITERARY MODELS.

ROSE M. KAVANA, TEACHER OF ENGLISH IN THE JOSEPH MEDILL HIGH SCHOOL, CHICAGO.

One who undertakes to discourse on the value of literary models as a method of teaching composition has to encounter at least two varieties of objection. He finds that a considerable number of English teachers do not believe in training the student to follow models of any kind. Another class are not opposed to the use of the imitative principle, but they regard with suspicion any attempt to make the work of the high school student literary.

Addison tells us of the "condition of a good man that had one wife who took a dislike to his gray hairs and another to his black, till by their picking out what each of them had an aversion to, they left his head altogether bald and naked." When some of my listeners have picked the literary and others the imitative element out of the method for which I am to speak, my subject, too, may be altogether bald and naked.

A letter which came to me recently regarding the teaching of composition expresses these two objections in the form in which one commonly meets them. "I do not believe," says the writer, "in the use of literary models. I think the method lays so much stress on the mechanical, arbitrary side that instead of developing it would decidedly retard originality. I think it is too far from the actual life interests of the boy and girl, too advanced in literary ideal to be practical in its results. I think that it is of more value to the boys and girls and to the city and the country that they should be able to discuss potatoes, and wheat and threshing machines, and street cars and griddle cakes than it is that they be able to discuss in a superficial or even better fashion the latest or even the best in literature and art."

Let us consider first the objection that the imitative method hampers originality.

It is a commonplace of psychology that we find the imitative and creative impulses closely united in the child. He has a double personality. On the one hand he is slavish in imitating all examples set around him by his elders, and on the other hand he is self-assertive, that is, creative. Nature has joined these two powers together in the individual, in his physical, social and intellectual life. He begins his existence with but few acts of skill, and it is by imitating his elders that he acquires the further acts of skill to be found in his social environment. In the course of his effort to copy these models he finds that he consciously or unconsciously introduces novelties into his imitations. This is the beginning of invention,

for the child sees that he is not entirely dependent upon models. He learns that he can turn out interesting products containing some element at least that is his own peculiar creation. Thus our inventions grow naturally out of our imitations, as variations on the type or model. There is such a thing as imitative invention. We are too much inclined to think of imtiation as merely slavish. The divine creator and the slavish imitator are constantly set in antithesis to each other and represent only the extremes. Between these two is the normal individual, with the sense of his own agency on the one hand, and his subjection to social copy on the other. He is a creator as well as an imitator, for if one has any gift of originality, he cannot copy slavishly. It is only the weak-minded who imitate without introducing modifications. "They are slaves because they cannot be anything else. Remove their bondage to imitation," says Baldwin, "and far from becoming free they would perish." Even the genius must subject himself to this law of social absorption, if his work is to receive the permanent sanction of mankind. He can make socially effective inventions only by making new dispositions of the forms, models, activities, organizations, accumulated by race experience and acquired by him through imitation.

We are too much inclined in our abstract discussion of methods of teaching composition to overestimate the amount of originality with which the ordinary student is endowed, and therefore to put the emphasis on the individual and creative rather than on the social or imitative factor. "Console yourself, dear man and brother," says Lowell, "whatever else you may be sure of, be sure at least of this, that you are dreadfully like other people. Human nature has a much greater genius for sameness than for originality." If then in the average boy or girl the imitative is stronger than the creative impulse, and if it is possible to develop the creative through the imitative, the use of models in the proper way is the most natural and least mechanical and arbitrary of methods. At any rate no one has ever discovered a method for teaching originality directly through precepts. "The only way to be original," says Stevenson, "is to be born so." "It is a piece of good luck, the good gift of the fairy godmother brings to her prime favorites in the cradle." All we can do for an original mind is to set it in motion by some external impulse and then direct it. For both of these purposes example is better than precept, for with an inventive mind imitation becomes emulation, the model becomes a challenge, and the product turned out is not seldom better than the model. A critic says of Chaucer, "We must let him if he will eat the heart out of the literature that preceded him, as we sacrifice the mulberry leaves to the silk worm, because he knows how to convert them into something richer and more lasting."

But with all the good things that may be said of imitation we must not ignore the fact that, like all other things, it may be carried to an extreme, by being made so narrow that no room is left for individuality. There must be a compromise between the two principles. Imitation carried beyond the normal will obscure the light of genius. An invention, on the other hand, that shows mere personal capriciousness and rejects the social restraint

which comes through familiarity with literature, that is, an invention not rooted in tradition, may be a thing of great ingenuity, but is not of social value and will ultimately be rejected and forgotten by society. Creations that contain no traditional elements are likely to be mere freaks. A socially effective invention includes not only the personal but the social factor. "Of abstract originality," says Lowell, "we will not speak till authors are raised by some Deucalion and Pyrrha process; and even then our faith would be small, for writers who have no past are pretty sure of having no future." The average high school class is not, however, composed of literary geniuses, so that the problem of curbing erratic invention is not an embarrassing one with us. With the average person imitation is needed not as a check on individuality but rather as an aid to it, for the child who does not imitate does not grow.

It will be readily seen by those familiar with the psychology of imitation, as set forth in the work of Baldwin and others, that I have thus far in this paper merely applied their views to the restricted field of the teaching of composition.

Let us now consider the other class of objectors, those who think we should not aim to make the high school student literary in his writing. They are not averse to the unconscious imitation of literature which comes from the reading and study of the English classics, for every one admits that the boy who reads much will express himself more fluently and correctly than one who does not. He grows because he unconsciously assimilates literary copy above him, transcends the forms of usage in his own social circle and the commonplace thought of every-day life. The random reading of Scott, Johnson, Goldsmith, Shelley, Emerson and a host of others who "added the stolen sweets of truancy to that of study," did more for their literary development than all the formal rhetoric they ever studied.

It is not about this unconscious absorption of literature that people differ, but about the set, conscious following of literary models. We find in reading the biographies of authors that when the time came for them to think seriously about writing as a profession, many of them turned from their habit of desultory reading to the conscious and avowed imitation of literary masters whom they acknowledge as having moulded their style and thought. This is the step some teachers think should not be taken by the high school, or even the college, student. The method of the science class, namely, experiment, observation and inference, is that of the professional scientist. The method of the drawing class is that of the professional artist, but if in the English class we talk about the methods used by writers in learning their craft we are very often thought to be impractical. There is a timidity about this matter that we do not find in the teaching of other subjects. Some of this prejudice against literary methods is due to a belief in the old dictum, *Poeta nascitur non fit,* more of it to the variety of meanings given to the term, the imitation of literature. We shall need to bring these various meanings before us in discussing the objections to a literary method in teaching composition.

To some the following of models means merely imitating the *style* of various authors. The objection to a system of composition based exclusively on the imitation of style is in my opinion well founded. Individual peculiarities of expression are subtleties beyond the analytical and imitative powers of immature students, especially of those of foreign birth. This kind of imitation is too minute and scrupulous to appeal strongly to their interests, and one who looks in their work for the unique word, or the "titillation of the foaming phrase" will look in vain. These refinements belong to more matured workmanship, and may be profitably sought only by those who have mastered the structural elements of the art. Besides, the finding of something to say is quite as much of a hardship as the mode of saying it, and the mere imitation of style does not help us to discover, select or organize material. To begin with the imitation of style is to invert the natural order.

To other teachers the imitating of literature means asking the student to write on subjects which have been treated in short selections by authors. L. Cope Cornford follows this plan in his book on Composition. He gives, for instance, a selection from Stevenson, entitled, "The House I Live In," and requires the student to write a description of his own home; another selection from Mark Twain, on "Cloud Scenery," and then says, "Let the pupil take an opportunity, as occasion serves, to observe some effect of atmosphere, light and cloud; and let him make as an exact picture in words as he can." This method does not of itself build up in the pupil's mind any well-knit system of rhetorical or constructive principles. It is suggestive and stimulating but lacks pedagogical sequence and unity. It does not give us the units of literary architecture, nor does it make the work on even purely rhetorical principles consecutive.

The writer of the letter quoted at the beginning of the paper expresses a third conception of what is meant by imitating literature. He says he thinks it more important that the pupil should be able to talk and write about practical and commonplace things than that he should discuss the latest or even the best in literature and art. To discuss the latest in literature is not to follow literary models. It is merely to use pieces of literature as material for expository themes. On the other hand, one may write about even such commonplace matters as street cars and threshing machines, in a literary way. Burns's "To a Mouse" is on a commonplace subject but does not lack artistic workmanship. To write about a picture is not to paint a picture. Neither is writing about a piece of literature the same thing as writing in literary form and spirit. Moreover, the commonplace furnishes quite as good material for literature as more remote subjects, though it takes a more skillful hand to give it novelty. We cannot escape being literary by discussing steam engines, nor can we become literary by writing about Emerson. Literary quality depends upon the attitude of the writer and the form his work takes. It is not a question of material.

A fourth kind of imitation to which objection may be justly made, is the following of individual authors. In working out a general plan suited to students of different tastes and aptitudes, one would be at a loss to know

what author or group of authors to select. "'Tis hard to find a whole age to imitate or what authors to propose for examples," says Sir Thomas Browne. We find from the study of literary history that this imitation of a master is the method most frequently used by writers in learning the technique of their art. Stevenson's testimony on this point is very often quoted: "I have played the sedulous ape to Hazlitt, to Lamb, to Wordsworth, to Sir Thomas Browne, to Defoe, to Hawthorne, to Montaigne, to Baudelaire, and to Obermann. This, like it or not, is the way to learn to write; whether I have profited or not, that is the way. It was so Keats learned, and there was never a finer temperament for literature than Keats; it was so, if we could trace it out, that all men have learned; and that is why a revival of letters is always accompanied or heralded by a cast back to earlier and fresher models. Perhaps I hear some one cry out: 'But that is not the way to be original.' It is not; nor is there a way but to be born so. Nor yet, if you are born original, is there anything in this training that shall clip the wings of your originality. There can be none more original than Montaigne, neither could any be more unlike Cicero; yet no craftsman can fail to see how much the one must have tried in his time to imitate the other. Burns is the very type of a prime force in letters; he was of all men the most imitative. Shakespeare himself, the imperial, proceeds directly from a school. It is only from a school that we can expect to have good writers."

If in our high school classes we attempted to carry out this plan and let each student choose his master, we should meet with a practical difficulty; for we should need to have as many text-books on composition as we had pupils, if they were at all varied in taste and capacity. Each book would be a guide for the imitation of a special author. If, on the other hand, we dispensed with the text-book and allowed the pupil to imitate his chosen author without direction, we should be presupposing more of the literary sense than our pupils in general are possessed of. It is only after they have learned a general plan of imitation that they can follow the individual master with profit. This method belongs, therefore, to a somewhat late stage of literary development.

A fifth kind of imitation we also find frequently in the works of authors. It consists in borrowing a hint here, a phrase there, and weaving them together in a design of the writer's own making. This may be called the mosaic method. "How pleasant it is," says Lowell, "to track poets through the gardens of their predecessors, and find out their likings by a flower snapped off here and there to garnish their own nosegays." The literary tact required to do this kind of work successfully is not to be found in the high school student. He is not able to make a unified design for his mosaic material or to put himself into what he borrows.

All of these five methods enumerated are valuable at some point in the development of a writer, but they are severally too narrow in scope, and not capable of sufficient organization, in laying a foundation in the secondary school for either literary production or appreciation.

We have thus far shown, first, that imitation is the basic principle in

the growth of expression; secondly, that socially effective creation grows out of imitation; thirdly, that when the student has assimilated and transcended the forms and thoughts of his every-day environment, as he should do, he must imitate literature if he is to grow. Contact with all kinds of authors is to expression what contact with the world is to manners. It is as true in composition as in other activities that "Home-keeping lads have ever homely wits." Fourthly, we have also shown that certain kinds of literary imitation are too one-sided or too advanced to serve our purpose as a general basis for the teaching of composition.

It remains to set forth in the brief time remaining a kind of literary imitation that may be made definite without being narrow, that directs without being mechanical, and that looks at literature not from the purely rhetorical but from the psychological and distinctly literary side, in such a way as to reveal to the student through literature the natural workings of his own mind.

To do this it will be helpful to use an analogy drawn from mathematics. Our arithmetical notation consists of the characters 0 to 9. These are variously combined to express all other numbers this side of infinity. The first step in learning arithmetic is to recognize the ten primary numbers, the next is to combine them so as to make them express the larger values. In like manner, in the study of composition we must begin by learning to recognize a number of literary units, not arbitrarily invented, but discovered in our own natural and universal mental processes, and illustrated in literature.

In narration, for instance, we find four species based upon the spontaneous movement of the mind in contemplating a series of events. We can think and tell of a series of happenings in the past—this is retrospective narrative; in the future, which is anticipatory narrative. We can follow two series of events happening in different places at the same time. This is simultaneous narrative. The fourth is forward-moving narrative, in which we start at a given point and follow events forward step by step.

In description, are found the units of place, personal appearance, character, mode of life, mood, etc. Exposition, Argumentation and Persuasion may be similarly analyzed, and illustrations of the units drawn from literature.

The next step is to find combinations of these units in the works of authors, for the combinations found in ordinary conversation are too often determined by the accidental and extraneous, and have, therefore, too little design for more formal purposes. After some familiarity with pieces of literature built up out of these units, the student should, however, be able to make effective combinations for himself. It will be seen that this method is based on literary analysis and synthesis rather than on the mere imitation of the externals of literature. The purpose is to put the pupil in possession of the working units of composition and gradually to free him from bondage to his model as he develops the power to make his own combinations.

In the development of this system of units and their combinations, unity

can be secured by making narration the fundamental form. The first themes written should be purely narrative, the next should combine narration and description, the next narration, description, and exposition, and so on.

In composition the structural and decorative aspects should be kept as distinct as in architecture. The tendency in the past has been to overemphasize the finish of a piece of work and to ignore some of the real problems of its organization. I do not wish to be understood as undervaluing nicety of workmanship in the use of the word, the sentence, figures of speech and the various other rhetorical matters. I am merely urging that the scope of composition be so enlarged that the pupil should be trained to handle literary as well as rhetorical units. We have been too much occupied with rhetoric, and yet innovations in the teaching of composition, like innovations in literary production, must not break completely with the past. The traditional work of the rhetorics on the units of expression and the requisites of style is all valuable. We need to conserve the best that has been done in this field with such modifications in treatment and such change in emphasis as may be necessary. This is our rhetorical heritage, but we can advance in the teaching of composition only when we recognize and add to it our heritage in literary methods. We must analyze the inventions in form and matter which we call literature, and with which the race has enriched itself, to find out the laws by which interest is held and attention economized.

PRESCRIBED AND VOLUNTARY READING OF THE ENGLISH CLASSICS BY PUPILS IN THE SECONDARY SCHOOLS.

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The title of my contribution is misleading because of its scope. I really wish to ask one or two questions concerning the method of teaching the prescribed selections from the English classics and to stimulate an inquiry into the results actually accomplished.

We shall all agree that English is taught more conscientiously, more earnestly, more systematically, more effectively, than ever before. But the best teachers of English are most willing to admit that they are still experimenting.

Two questions have forced themselves upon me whenever I have considered the work of an individual teacher of English or the outcome of our English teaching in general. First, does the reading of the prescribed selections from a certain author stimulate the appetite for reading more of his work; and, second, what effort is conscientiously made by the teacher to influence the pupil's style of English speech and composition by the loving study of the style of the masterpiece?

I am not in a position to speak intelligently about the first matter. Are any of us prepared to do this in such a way as to justify a hearing? If not, ought we not to consider the question seriously? If the pupil's study of the best English masterpieces creates no passion for more reading of the same kind, if he finds relief from the tedium of an unwelcome daily task by reading cheap and worthless literature, we ought to know the fact. If he developes the dangerous habit of omnivorous and haphazard reading, that fact ought to be known and to have weight in the adoption of practical methods in the class-room. We can not boast of the results of our teaching until we can show that our pupils are learning to despise and shun the latest ephemeral novel, to cease gorging upon the heterogeneous mixture presented by our newspapers and magazines, to reject that which is simply fashionable, and to hold fast to that which has been proved to be eternally good. If the reading of the prescribed classics does not lead to the habit of voluntary reading of the same kind of literature, then we or our methods are at fault. How many of us set such an example in this important matter that our pupils will be able to imitate us safely? We can not create a passion for the reading of Scott if we do not read within a year any other novel than the one set for the pupil's study. What ought to be to him a source of joy will be only a task because it is clearly such to the teacher. If the teacher of English is only a prosaic, unimaginative Gradgrind, he will kindle poetic fire only in the hearts of children who reluct and revolt against him and discreetly admire the things that they know he dislikes. But there are few teachers who deliberately condemn the author whose works they teach. Most of us see clearly that an affectation of contempt for a classic in self-condemnation. We ought all to see that the surest way in which to create an appetite for the best reading in our pupils is to cultivate such an appetite ourselves and to win them by the contagion of our own enthusiasm.

Let me consider briefly the second question. What efforts are we making to influence vitally the style of our pupil's speech and composition by a thorough, conscientious, and sympathetic study of the style of an author whose works we are reading? I do not refer to a critical hunt for misplaced commas, grammatical solecisms, incongruous metaphors, or any other violations of rules laid down in our grammars or rhetorics. People who echo the cheap criticisms of the literary style of Macaulay, or Ruskin, or De-Quincey only air their own foolish vanity. Let us take it for granted that the pupil who approaches one of these masterpieces, whether of prose or of poetry, has a sound training in English grammar and that throughout his secondary school course he is receiving regular instruction in what has commonly been called rhetoric. But let us also assume the reliability of the judgment shown by the generations that have deemed a literary masterpiece worthy of immortality. The vocabulary of English speech grows constantly. Words and phrases acquire new meanings and lose old ones. But it is safe to say that any man who lovingly studies and deliberately imitates Shakespeare, Milton, Dryden, Addison, Byron, Macaulay, Carlyle,

Lowell, or the King James's Version of the English Bible will develop an effective English style just as certainly as Franklin or Ruskin did by conscious or unconscious imitation. May we not say that the end of all the English work of our pupils, the finest flower of all our English training is the acquisition of an effective style? Of course it is true that in a sense the style is the man or woman. It is also true that if one has things to say and is properly trained he can say these things in such a way as to command a hearing. But we are not "trustees of civilization" if we teach our pupils that a crude and raw expression is consistent with noble and worthy thought. The best thought is impossible without worthy expression.

I fear that the colleges have led the schools somewhat astray in this important matter. The amount of reading prescribed for careful study is not small. The questions set for examination for admission to the colleges show that the examiners are concerned almost entirely with matters of interpretation. The questions deal with history, mythology, psychology, and dramatic criticism; but hardly a question is ever asked that concerns itself with the effectiveness of the author's style, and in marking the candidate's paper the weary examiner is compelled to use the blue pencil solely upon misspelled words, misplaced marks of punctuation, and grammatical errors.

The teacher in the secondary school judges of the college ideal by the character of the examination. This influence is felt only indirectly in this favored region where entrance by certificate has so largely banished the older method of college admission. But the indirect influence of the older system is still great even in schools that send graduates only to our state university or to other institutions that have been converted to the more excellent way. College entrance examination boards have a more vital influence upon the English teaching in our schools than any other agency. Yet in twenty sets of college entrance examination papers recently examined by me, including those of Harvard, Yale, Princeton, Williams, Amherst, Mount Holyoke, Bryn Mawr, Wellesley, Pennsylvania, Michigan, Chicago, Wisconsin, Illinois, Minnesota, Leland Stanford and the College Entrance Examination Board, which speaks for most of the collegiate institutions along the Atlantic seaboard, I have found hardly a question directed toward the discovery or the appreciation of a single beauty of style. Of course it is true that thought precedes expression. I am not pleading for the ignoring of the author's thought for the purpose of emphasizing the need of attention to the form of expression. No masterpiece is worthy of immortality that is not ennobled by the dignity and strength of its thought. But the really great authors have been able to vivify the trivial and the commonplace by the vigor and charm and simplicity of their own style. Can we read The Cotter's Saturday Night, The Deserted Village, Evangeline, or The Vicar of Wakefield without learning this lesson? Of course we all know this. But how many of us make it a part of our daily life? How many professional teachers of English linger lovingly over the beauties of a classical author and try to communicate the contagion of their own joy

to their pupils? How many pupils begin to show a dawning appreciation of style while in the secondary school? How many college students can confess to an appetite for a delicately phrased sentence or a well-rounded paragraph?

It is true with this matter, as it is with that spiritual process known as conversion, that the normal and healthy boy or girl can not locate the exact moment when this sense of joy in the use of words first became consciously recognized. Yet most of us can tell who first stimulated the quick development of the sense. The enthusiasm of some one who loved literature for its own sake, father, mother, teacher, or trusted friend, this is the provoking cause of this wonderful pleasure. And so I am not pleading for methods. Let me rather state my sincere conviction (here as in the other matter) that in the teaching of English the personality of the teacher counts for more than in any other work of our schools. Pupils will not develop a passion for the best reading if the teacher is pleased with commonplace and trivial stuff; pupils will not reverence and love the literary style of a master till they have seen the fires of reverential love blaze upon some altar reared by genuine enthusiasm.

HISTORY SECTION

THE TEACHING OF CIVICS IN THE HIGH SCHOOL.

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We are told that during the Age of Pericles every Athenian citizen was qualified to hold civil office and ably to direct the policies of state. Certainly this cannot be said of American citizenship at the dawning of the twentieth century. Furthermore, a condition exists that suggests the ravages of a fatal disease rapidly working its way to the very vitals of the body politic. It is not necessary to describe here a situation that is so well known to us all. There is enough of political ill in our land today to demand, upon the part of those who are intrusted with the education of the youth, most careful consideration. There is a demand for a better understanding of our political institutions,—their history, their purpose, and their actual working. Amid all the political isms of the day some intelligence should direct the rising generation. With the dangers so evidently before us, some guiding hand should point the way. And when we look behind the screen of laws and constitutions, and behold the trusts and politicians building up a system of bribery that bids fair to become an American institution itself, and realize that in public life the "highway of corruption is the road to success," then, we appreciate the need of a higher moral standard of living,—a more righteous citizenship.

Many men look back upon the history of our country and are proud of her glorious achievements, their hearts respond with swelling pride as they recall the names of her great men, and when her honor is attacked stand ready to die in her behalf. Yet, how many can be found who, knowing of the enemies within her borders that are undermining her very foundations and bringing shame upon her flag, are willing to sacrifice even a small part of their time for her sake? As Josiah Strong has put it, "we are in need of a new patriotism,—one that prompts men, not to die for their country but to live for it, which is as much more heroic as it is difficult." Wherein lies the salvation of our country if it cannot look to its public schools to teach the kind of patriotism that is most needed? It may not be possible for us in our day, to reach the civic perfection of the Age of Pericles, yet our system of education is at fault if it does not strive, so far as it may, toward that much to be desired goal. We are attempting this very thing in all that we teach, but is it not possible through a proper teaching of Civics, to do even more than has yet been accomplished?

The high school holds a unique place in relation to this subject. Comparatively few students who attend college will give attention to it, and little can be done in the lower grades beyond gaining a familiarity with the nomenclature of political science. In the high school we reach the largest number of pupils who have attained an age of experience and appreciation sufficient to take up the subject in a practical manner. It is here that we may expect the largest results. The public high school is supported by the taxpayers, and is in duty bound to make the best possible return for the investment made. The public certainly has the right to expect an annual installment of intelligent, conscientious citizens, fully realizing their obligation to the community in which they live.

Practically all authorities have accepted the demand for a course in Civics in the high school, and by almost universal consent it forms a unit with American history, and is offered in the twelfth grade. A few schools are still giving this subject below the twelfth grade, but are rapidly coming to realize that it can, under the circumstances, be little more than a review of the manual of government, and that the time might better be spent upon some other subject.

Before we can attempt to solve the problem before us, we must consider the varied conditions with which we are surrounded. While the course of study may be uniform, there may be a great difference in the work actually done. The number of pupils in the class, the number of teachers necessary to conduct the work, the location of the school, and the library equipment are all important factors in the character of the work attempted. The student himself must also be taken into account. What are his home influences? What advantages of progressive historical study has he had? What has been his training and experience in the use of a working library? But the most important element is the teacher. Is he specially prepared to teach the subject? Is he also the teacher of American history? Has he several other subjects to handle at the same time and in no way related to Civics?

Is he himself enthusiastic and the kind of citizen that he would make of his pupils? We may classify these conditions approximately by the general terms,—the small school and the large school. The small school presents to us a few students, probably one class in the subject and a small number of works in the library. The student has had little opportunity to develop historical methods of study and he may or may not have become familiar with the forefunners of our political institutions. In all probability the teacher has not specialized in the subject and is called upon to teach several others at the same time. On the other hand, in our largest schools we may find enough students taking the course to demand the entire time of one teacher or at least the teacher of American history, who may have specialized in his subject and can give his whole energy to his work. The school is equipped with a large and choice working library. The student has followed the work in history through the Ancient and European units, and in the work in English history has studied the origin and development of those principles of government and those very political institutions that are our own today. He may have taken a special course in the use of a library until he is prepared to do intensive work and to do it well. These two extremes and probably all intermediate stages are to be found within our state. This makes it impossible to lay down a rule by which all may be guided. Each teacher must meet the conditions bravely, and, with an ideal before him, strive to make the best of them.

The problem that first presents itself to the teacher is how to cover the ground of both American history and Civics in one year, and at the same time to accomplish the purpose and intent of each subject. The student in most instances is prepared to do an advanced grade of work, and the opportunity should not be denied him. Two general plans may be adopted, —a single course combining the two subjects and two separate courses. To combine the two subjects would mean that one would become an adjunct or side issue of the other. The chief difficulty seems to be to find a satisfactory point at which to take up the very important division of local government and municipalities. Objections to the plan are that the continuity and logical development of one or both subjects may be sacrificed, the attention of the student is more or less scattered and little opportunity is offered for intensive methods of study. However, this may be the only feasible policy to pursue for many schools, its success depending almost entirely upon the teacher. To conduct the courses separately is ideal and yet it also has its drawbacks. Then the question arises, how can the ground of either course be covered in one semester? The experience of many is that with the ordinary text-book in American history, beginning with the Age of Discovery, and with methods adapted to the ability of the twelfth grade student, the term will close with the class just beginning the period of the Civil War. The study of American history in this day and for this generation should not stop here. Also, if the course in Civics is studied from the historical standpoint, the student is covering again the Colonial and Revolutionary periods. This is an unnecessary repetition within a year. If five recitations per week are given, three

may be taken by American history and two by Civics. One plan which has been tried with success when four recitations per week are given is as follows: The so-called Colonial Period of American history is taught as a part of English history in the eleventh grade. This is, from the historical point of view, the logical way to treat the English Colonies in America up to the time of their independence, and it certainly gives the student a more truthful view of the history. Then in the twelfth grade the course in American history begins naturally with the constitutional period and reaches satisfactorily the present administration. The course in Civics follows as a history of American political institutions. In this way a thorough review of the Colonial and Revolutionary periods is given as the following topics will show: The New England Township, the Southern County and Parish, The Hundred of Maryland and Delaware, The Mixed Type of the Middle Colonies, Steps Toward Independence, Colonial Central Government, Transition from Colony to State, Steps Toward Union, The American Congress, The Federal Convention, etc. The work of the preceding year and a half is here welded into a whole and applied to the present. This scheme may not appeal to all, but we must consider that what will work successfully in one school may not be at all adapted to another. Once more each of us must meet the conditions with which he finds himself surrounded, and work out his own solution of the problem.

Another question worthy of consideration is in regard to the relative proportion of time to be given to the main divisions of the subject. Most of our text-books give the larger space to National institutions and comparatively little attention is paid to local government and municipalities in particular. We do not expect many of our students to become statesmen or to deal to any great extent with national institutions, but we do expect all of them to become citizens of some city or locality in need of loyal men and women. There is no longer any danger of lessening fidelity to the nation by putting emphasis upon state and city patriotism. If we believe that "in the vitality and strength of our local institutions lies the political stability of our country," can we not best serve the interests of our whole political organization by giving more of our time to a study of the conditions and actual working of the government immediately round about us?

It has been agreed that the relation between history and civics is very close, yet it may be necessary to emphasize the fact that the historical development of our institutions should not be slighted. The student should realize that they are a growth, organic in nature, that they have their roots extending deep down into the past, and are not to be ruthlessly hewn down. He should appreciate the character of that growth, the putting forth of new branches to meet the demands of a progressive civilization, and the process by which the unwritten constitution becomes a visible part of the complex system. He should know the value of public sentiment and should not be led to place too much confidence in the written law or even the constitution itself. As Professor Bourne has said, "it would be truer to teach that we started with a written constitution which shifting political conditions speedily

began to reshape." Thus the saying that "it is the duty of every generation to gather up its inheritance from the past, and thus to serve the present and prepare better things for the future," is particularly applicable to the study of Civics. A better name for the course might be "A History of American Political Institutions."

When taught as a course in history we may claim for Civics practically all of the educational values of that subject. It develops the imagination, the love of truth, and the power of historical thinking and reasoning.. It trains the student, not only in the use of books, but also in original investigation and personal observation of political phenomena. It arouses an active interest in the life of the community in which he lives. And added to these historical values is the intensely practical aim of the subject,—a means of fitting the pupils for the performance of the duties of citizenship and of cultivating in them an enlightened patriotism,—the "new patriotism" so much needed today. As Lincoln Steffens has just said of the great business men of our country, "they simply do not know what patriotism is. They know what treason is in war; it is going over to the enemy, like Benedict Arnold, and fighting in the open against your country. In peace and in secret to seize, not forts, but cities and states, and destroy, not buildings and men, but the fundamental institutions of your country and the saving character of American manhood—that is not treason. That is politics. and politics is business, and business, you know, is business." What a comment upon the existing standard of public morals! The ethical value of Civics when porperly taught, cannot be denied. Here the student recognizes his own relations to society. He is made to understand the obligations that rest upon him as a member of a community, and this knowledge tends to arouse in him a higher standard of moral action. The truth of this may in part be seen in the efforts of our young college men who are today exerting a most wholesome influence in public life. This is not intended for the boys alone but just as much for the girls. This is well illustrated by the yell given by the girls of a co-educational institution before whom Mr. Folk of Missouri appeared to give an address:—

"Joe Folk! Joe Folk!
He's the man,
If we can't vote
Our sweethearts can."

We may fit both boys and girls only indirectly for citizenship, but we may through them lay the foundations for a sound public sentiment, and this after all is the great hope of our political salvation.

The method of teaching Civics, like other problems, depends upon conditions. In general a text-book, when a good one can be found, is in the high school a very desirable help. Several books of merit have recently appeared and more are promised. The difficulty with the ordinary text-book in Civics is that it is written for general sale and is strong only on the national government. The very nature of the subject makes the text-book of minor importance. Our state and local institutions are widely varied and

are constantly changing. Even the national government is gradually expanding its powers, so that we soon realize that the subject is a progressive one and that text-books can hardly keep up the pace. We must teach more than any general text-book can well contain because it is the actual government rather than the theory that we are after. It is pedagogically wrong to teach the youth the theory of government and then send them out into the world to find that the practice is something quite different. The text must be supplemented in various ways in order to put the necessary data into the hands of the students. A choice collection of national public documents may be had for the asking. The state manual with its constitutions, historical sketches, records, maps, reports, pictures, duties of officers, departments, and institutions is a most valuable book. For local government the compiled laws, reports of officers, blank forms used in public business, municipal and department manuals, and the newspapers afford all that can be desired and practically without cost. The student, provided with this source material should, with a fair reference library, be expected to accomplish very satisfactory results.

In regard to the practical value of Civics, we have an opportunity, as in almost no other subject, to bring the student into direct contact with the actual demands of his future life. One of the most valuable aids to the course is a well planned and executed system of student reports. Most of our high schools are located in cities and possibly county seats. If so the student has a perfectly equipped laboratory in which he may work out by original investigation, the theories and principles which he has studied. The character of these reports will be recognized by the following suggestions: A brief report of the actual working of some public office obtained from the laws, the reports, and a personal visit to the office; A report on the method of transacting some actual public business with the blank forms used properly filled out; A report on the passage and execution of some particular law or ordinance with personal observations as to its proper execution, and if not properly executed an opinion as to where the responsibility should be placed; A brief or formal argument for or against some change in the existing forms of government as suggested by the various reform movements. If the student is prepared for the work, longer reports or theses form a very valuable source of training. The subjects should be chosen at the beginning of the semester, work upon them should be continuous, and liberal credit should be given for the result obtained. This work should be original in character and historical, if the source material be obtainable. A few such topics follow: An account of a spring or fall election; The process of taxation in the city or the county; A history of some office or department; Some event in local history; A criminal or civil process at law, etc. Another good scheme is a newspaper clipping note book, in which are kept all clippings bearing upon the work, with comments upon their application to the theory and practice of government. And in this respect the newspapers, which are our public watch dogs, exercise a very wholesome influence. The field is almost unlimited and every teacher who is thoroughly

alive to the possibilities of the subject will find in these reports an inspiration, and will find the students eager and enthusiastic in their work.

In conclusion then we should recognize the need of our country and the opportunity of the high school to serve its best interests. We should strive to improve the existing conditions, the equipment of the school and the preparation of both student and teacher. We should keep before us the responsibility and noble purpose of our work, and with high ideals. employ such methods as may seem best fitted to accomplish the desired results. These methods should aim to bring the student into contact with the actual working of the government in order to emphasize the practical and ethical values of the subject. It should be taught as a separate course wherever it is possible so to arrange it, and placed in the last vear of the high school curriculum. It should prove to the student a means of historical review; it should give him a correct notion of the unity of all history; it should equip him with the weapons of peaceful warfare and inspire him with a desire to serve his city and his country as an independent, intelligent, conscientious citizen.

THE RELATIONS BETWEEN THE TEACHING OF HISTORY AND THE TEACHING OF GOVERNMENT IN SECONDARY SCHOOLS.

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My text will be found in one of the admirable series of lectures on political science by the late Sir John Seeley of the University of Cambridge (England):

> "History without political science has no fruit,
> Political Science without history has no root."

The subject before us is simply the elementary teaching of political science; and these statements in reference to the more advanced subject are equally true in referenc to its more elementary treatment.

I shall take up the two statements in inverse order. And the first point I wish to establish is that the teaching of government, or politics, or political science—whatever it may be called—must be grounded and rooted in history. The attempt has sometimes been made to treat the two as entirely distinct, and to teach government as it exists today merely as a descriptive subject without reference to the past. To do this is to ignore one of the most fundamental facts concerning political institutions, the process of development or evolution, which is no less true of political organization than it is of animal life. Without a knowledge of the historical conditions which explain the origin of institutions and a study of their historical development, it is impossible to understand how our present system came to be, or why many of the existing institutions and laws are as they

are. Without a knowledge of history, it is impossible to realize that this process of development is still going on; and to teach simply the present is to convey an erroneous impression as to the fixity and permanence of the machinery of government. History, too, emphasizes, or should emphasize, the relation between social and industrial conditions and political institutions, and should thus make clear that as the former change the latter may also have to be altered. In all of these ways, then, history is an essential preliminary to adequate work in the treatment of civil government. As Bishop Stubbs has said: "The roots of the present lie deep in the past, and nothing in the past is dead to the man who would learn how the present comes to be."

But, more than this, many of the important topics that are connected with a knowledge of our government and political conditions can be taught in the history course, and some things can be better taught there than in a systematic treatment of present institutions. The course in English history can make clear many features of our political system, such as the safeguards of individual liberty in their development from Magna Charta to the Bill of Rights, the origin and development of judicial courts, and the growth of representative institutions. And the course in American history can explain such matters as the colonial beginnings of local government, the causes which brought about our federal system of government, the general nature of the federal system, the admission of new states, the history of parties and their leading principles; and such topics can be more fully explained in connection with the historical events of the time than in an analytical account of the governmental organization of today.

Moreover, the work in history, or at least a good part of it, should precede the systematic study of civil government in secondary schools. In the elementary schools some merely descriptive instruction in government may be taught in connection with other subjects; but for the more thorough course which secondary schools should offer there are three reasons why the history work should precede. In the first place, the narrative of events which history presents is simpler and easier to understand than an analytical exposition of a political system; and thus lends itself to the earlier stages of instruction. In the second place, the historical facts form much of the material for the analytical discussion: and it is in accordance with scientific method to collect material before attempting to classify and arrange it. To follow the opposite order involves *a priori* assumptions, and inculcates erroneous habits of thought. In the third place, if the teaching of government is to have the largest possible influence in training in the rights and duties of citizenship, it should be taught in the most advanced stage of the school work. If taught in the lower classes, some of the more difficult questions must be omitted or treated in a less satisfactory way than can be done in the upper grades of the same school.

If, then, I have demonstrated the importance of history as a basis for teaching government, it is equally important to emphasize the other part of the text,—that the study of history without some study of political institu-

tion or government is incomplete and misses one of its most important purposes. While in some places civil government has been taught without any basis in history, in others history has been taught without any special work in government, on the ground that all the essential points in the latter can be taught incidentally in connection with the history work; and this latter claim has been implied, if not openly set forth, by some whose statements are likely to carry weight. In my opinion the one view is as mistaken as the other.

The importance of systematic work in government can be shown from general considerations. To be satisfied with the work in history is to assume that the modern scientific method is entirely mistaken, or at least that it is adapted only to the physical and biological studies, and is inapplicable to social and political facts. To state this alternative seems to me sufficient. For I do not think that any one who understands the situation will deny that the same advantages of classification, comparison and analysis apply to the latter field as fully as to the former.

A more specific examination of the particular question will lead to the same conclusion. The study of political history or political institutions by any method as a part of school instruction may be urged on two grounds. In the first place, on the general basis which underlies all education,—for the purpose of securing a knowledge of our environment. In the second place, and in particular, because in a country like our own where the government is based practically on a system of manhood suffrage, and where good government depends on an intelligent and honest exercise of that suffrage, it is essential that the people should understand their rights and duties as voters and citizens and their relations to the government. And if even a small proportion of the citizens are to learn of these things in any other way than through the biased and partisan statements made in the heat of political campaigns they must be placed on the right road in the schools.

That the study of history is an essential part of this necessary training on both grounds I have already indicated. But does this alone give an adequate conception of our political environment, of the rights and duties of citizens, and of their relations to the government? To be sure that my own impression as to what is now covered by a course in history was not mistaken, I have examined some of the most recent text-books in history, and I think I am safe in saying that a course in history still fails to deal with the political environment which is nearest both in time and place, and still fails to acquaint the citizen and voter with many important facts in reference to the government and his relation thereto.

I have already indicated some of the topics connected with the study of government which can be and are considered in a course in history. But in addition to these, there are others of equal importance which are not considered in such a course. Such, for example, are the origin and justification of political societies, the fundamental principles of law and justice, state government—in particular the work of the legislatures and the courts, local government—especially in the cities, the functional activities of govern-

mental officials, the acute political problems of the present, the organization of party machinery and its influence on the working of political institutions. All of these matters are certainly of equal importance with those covered in the course in history; and they include those parts of our political system which most largely affects the daily lives of the citizens, and those which can in turn be most directly controlled by the voters at the polls.

In reference to the one subject of state government, which is entirely ignored in high school courses on history, Woodrow Wilson, now President of Princeton University, has pointed out that:

"All the civil and religious rights of our citizens depend upon state legislation; the education of the people is in the care of the states; with them rests the regulation of the suffrage; they prescribe the rules of marriage, the legal relations of husband and wife, of parent and child; they determine the powers of masters over servants and the whole law of principal and agent, which is so vital a matter in business transactions; they regulate partnership, debt and credit, and insurance; they constitute all corporations, both private and municipal, except such as fulfill the financial or other specific functions of the federal government; they control the possession, distribution, and use of property, the exercise of trades, and all contract relations; and they formulate and administer all criminal law, except only that which concerns crimes against the United States, on the high seas, or against the law of nations."

Not only are such subjects as I have mentioned omitted in the present treatment of history, but it does not seem possible to consider them adequately and to give a satisfactory idea of our present political system by any historical method. History necessarily looks towards the past and surveys a succession of events. A satisfactory treatment of government must look primarily at present conditions and describe a rather complicated mechanism of political organization. The two things are closely inter-related; and I have tried to show how the study of government requires a knowledge of history; but nevertheless the two are distinct, and each can be more easily understood and a knowledge of their mutual interplay can be more easily gained if they are studied as separate subjects.

One serious difficulty in teaching civil government incidentally in a course in history in this country is presented in the character of our government. Doubtless one reason why our text-books and courses in history fail even to mention state and local government after the Revolution, is that it would complicate and confuse the account of national history to combine with it the internal political history of forty-five different states and systems of local government,—for in spite of certain large tendencies in common there are many wide variations between the different states. While, if such a history were prepared, it would overburden the young students with information about other states, which will not directly concern them in the exercise of their political privileges. But by separating the work in government from that in history, it is possible to deal in the government course both with the national government as a systematised whole, and also with the government of the particular state of immediate concern to each particular

school; and to do this in a way that will give some definite notion of each, and of the relations of one to the other.

I shall not attempt to discuss in detail the outline of his course in Government, which Mr Davis has so well described. The essential points of his plan I can endorse, since they are in accordance with what I have said. He bases his course on a thorough foundation of history; but at the same time has recognized that the study of government must be treated somewhat apart from the narrative history, and by the analytical rather than the narrative method; and he has emphasized, what can only be emphasized by such a method, the importance of state and local government. On minor details, as to the precise division of labor between the history course and the government course, there is room for some difference of opinion; and the final conclusion on these points must rest largely on the experience of secondary school teachers.

On one other point I may add a few words,—on the importance of adequate and special training on the part of teachers for work in civil government. Until recently, it must be confessed, our colleges and universities have not offered opportunities for special training in this field; and those now teaching must equip themselves, by studying not merely school textbooks on government, but also more advanced works on political science, current literature on present politics, and the constitutions, statutes and other original sources on political institutions and their working. Those still receiving their preliminary training have now larger opportunities for special training in this field than formerly. And there can be no doubt that the same advantages which result from specialized training in other branches of educational work are to be secured also in this particular subject.

MATHEMATICAL SECTION

MATHEMATICS IN THE HIGH SCHOOL COURSE.*

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I enter a discussion of this feature of a High School Course with some hesitation, for I appreciate, partially at least, the many factors which must be considered in outlining such a course of study. I realize that the first requisite is a comprehensive view of the whole situation, and having obtained that, one must concentrate his attention on a specific detail of the view, without losing sight of the whole. This, I take it, must be a general attitude of the true teacher.

*This paper is a discussion of the preliminary report on a High School Course, presented by the Commission of the State Teachers' Association at the meeting in December, 1903.

Much has been said and written in recent years on the scope and purpose of secondary schools, especially public high schools. A part of this discussion has focused on the idea as to whether the course of study is to be arranged on the basis that the high school is to be the "finishing" school of the majority of those attending, or whether the school is to be considered as merely preparatory to something higher. I have no desire to reopen the discussion, and will allow the Committee of Ten to formulate my position, in which I think you will all, in the main, agree: "The Committee of Ten unanimously agree with the Conferences. Ninety-eight teachers, intimately concerned either with the actual work of American secondary schools, or with the results of that work as they appear in students who come to college, unanimously declare that every subject which is taught at all in a secondary school should be taught in the same way and to the same extent to every pupil so long as he pursues it, no matter what the probable destination of the pupil may be, or at what point his education is to cease. Thus, for all pupils who study Latin, or history, or algebra, for example, the allotment of time and the method of instruction should be the same year by year. Not that all the pupils should pursue every subject for the same number of years; but so long as they do pursue it, they should all be treated alike. It has been a very general custom in American high schools and academies to make up separate courses of study for pupils of supposed different destinations, the proportion of the several studies in the different courses being various. The principles laid down by the conferences will, if logically carried out, make a great simplification in secondary school programmes. It will lead to each subject being treated by the school in the same way by the year for all pupils, and this, whether the individual pupil be required to choose between courses which run through several years, or be allowed some choice among subjects year by year."

In making a course of study like this, I presume that, after settling what specific part the school is to take in the development of the pupils, the next step should be to determine what studies would best accomplish such development. Here, again, I have no desire to present at this time the claims of mathematics as well adapted for this or that discipline. The Committee of Fifteen on Elementary Studies place the study of mathematics side by side with language study, claiming for it a place second only in importance to that of language. The programme of every secondary school in the land furnishes evidence of the high place of importance given to mathematics. The allotment of time, I take it, is a very important matter of administrative detail, one which presents many difficulties, which requires a clear comprehension of the comparative claims of many subjects, and which must often be modified, more or less, by local conditions. With a half-year of algebra in the grades, together, I presume, with more or less experimental geometry in connection with drawing and otherwise, an allotment of fifteen year-hours for algebra and geometry is not far from a fair and equitable one.

I am not sure as to the significance of the words "course of study"; whether it means a course which should be more or less closely adhered to,

or whether it means a course which should serve as a "norm" or basis upon which to build a specific course. From conversation and correspondence with some teachers, I have inferred that the former was intended, for some have indicated their approval of the plan on the ground that, if it were generally adopted, the problem of arranging the studies of pupils moving from one city to another would be greatly simplified. If the latter idea is that of the Commission, it would be easier to discuss; for I could then substitute the word "mathematics" for algebra and geometry, and leave the distribution to the individual school. At any rate, as the distribution of algebra and geometry is to be discussed later, I shall adopt this course.

In the development of our educational system we passed through an epoch when more advanced mathematics were scarcely known in our schools, so that the course in arithmetic was expected to include all that the pupil would ever know of mathematics. With the usual conservatism of educational practices, these methods continued when the more advanced subjects were introduced. It soon became evident that there was, then, no sound reason for the retention of a considerable part of the arithmetic course, and educators charged with making model schedules of work, proposed abandoning a part of it. Foremost among those who advocated this, was the Conference on Mathematics, who reported to the Committee of Ten as follows: "The Conference recommends that the course in arithmetic be at the same time abridged and enriched; abridged by omitting entirely those subjects which perplex and exhaust the pupil without affording any really valuable mental discipline, and enriched by a greater number of exercises in simple calculations and in the solution of concrete problems." As a consequence of this, or better said, simultaneously with this, arithmetic was relegated to the grades in many schools, some persons believing that it can and ought to be finished in the first six grades, others advocating its continuance through eight grades. It may be here added that this does not include so-called "commercial" arithmetic, which is given in connection with commercial courses.

In spite of this, there seems to be a tendency to keep a distinct place for arithmetic in the high school course. In order to ascertain the sentiment of school men on this subject, Professor Lyman and I sent a circular containing this inquiry to school men of the state, mostly principals and superintendents: "Should arithmetic be taught in the high school as a part of mathematics?" The weight of the replies answers the question in the affirmative. Of the forty-one replies received to date, *five* answered decidedly *no; six* answered *yes,* as an elective, and *twenty-five* answered *yes,* without apparent qualification.

How much of this is due to natural conservatism and persistence of educational traditions, or how much to the feeling that the work is not and cannot be satisfactorily done in the grades, it is difficult to determine. I wish I were wise enough to suggest the right course. Sometimes, when I have been annoyed by having the fine point of a beautiful problem in analytic geometry misshapen and blunted by the inability or slowness of a pupil to

add or divide two common fractions, I feel like vigorously advocating arithmetic in the high school. My present feeling on the subject may be expressed somewhat as follows: If the work in arithmetic were done as might reasonably be expected in the grades, if a proper review of arithmetic were opportunely made and emphasized in connection with algebra and geometry, thus enlivening and enriching all three subjects, and if sufficient time were given to do this, then the high school course might omit a formal place for arithmetic. I have in mind a course in mathematics, while others may be thinking of courses in arithmetic, algebra, or geometry.

Most of our engineering schools, and some of the medical schools, which have not set the standard of admission as high as a bachelor's degree, require plane trigonometry for admission. Some schools are doing this work, and it appears on the surface that there should be a place where this could be inserted. It is important enough to receive consideration at the hand of the Commission.

I have been all too long coming to the specific report of the Commission. The course is built on the unit plan, five hours per week for a year in mathematics counting as a unit. It is supposed that a half-year of algebra has been done in the grades, presumably in the eighth. In the ninth grade is placed a year of algebra, five hours per week; in the tenth, a year of geometry, five hours per week; in the eleventh grade no allotment is given to mathematics, but in the twelfth grade is a half year of algebra followed by a half-year of geometry five hours per week during the year. As stated before, I shall not discuss the distribution of subjects feature of the course.

An important defect in the course centres around the gap in the eleventh grade. This appears to me an application of unsound pedagogical principles, which will necessarily impair the results. I consider that the Commission should make a strenuous attempt to remedy this defect, for a discontinuity of twenty-seven months in the study of algebra and a discontinuity of twenty-one months in the study of geometry are imperfections which need only to be mentioned to be seen.

If one turns to the Report of the Committee of the N. E. A. on College Entrance Requirements, he finds suggestions for the arrangement of the course in mathematics from the seventh to the twelfth grades, inclusive, as follows:

Seventh Grade—Concrete geometry and introductory algebra...4 periods
Eighth Grade—Introductory demonstrative geometry and algebra.4 periods
Ninth and Tenth Grades—Algebra and plane geometry.....4 periods
Eleventh Grade—Solid geometry and plane trigonometry.....4 periods
Twelfth Grade—Advanced algebra and reviews.....4 periods

The course under discussion has many of the features of this suggestion. Plane trigonometry is taken out of the eleventh grade, advanced algebra out of the twelfth grade, the solid geometry of eleventh grade is pushed forward to the twelfth grade, leaving the eleventh entirely open, and one hour or period per week is added in each year of the high school course. In this

way, the required subjects are obtained, but the continuity of the other programme is destroyed.

I suppose it devolves upon me to say something in the way of suggestions of a better course, a difficult and delicate matter. I have said that I considered the allotment of time a fair one, and by that I abide. Fifteen year-hours, or if you grant an additional one for reviewing arithmetic, sixteen year-hours will serve as a basis of reckoning. The easiest way of distributing this is four hours per week throughout the four years. The administrator here says that it cannot be administered. Not on the five-hour unit basis truly, but is this the only way possible?

Professor Lyman and I also asked the question, "Should mathematics be taught continuously during the four years?" The answers to this question were about equally divided between the affirmative and the negative. Many of those answering in the affirmative included arithmetic in the course in mathematics. I inferred from explanatory remarks that a number of those answering in the negative did so under the impression that five hours per week for the entire four years was intended. I think most of us would agree with the latter under this supposition. Some Michigan schools follow at present the plan of omitting mathematics from one year of the high school, but I know that in some cases this has proved unsatisfactory. In others algebra and geometry are omitted in two semesters not consecutive, arithmetic being given either as an elective or required study in one of them.

As a compromise with the five-hour unit basis, I would suggest the following:

	Grade	IX	X	XI	XII
	Hours	5	5	3	3
or		5	4	3	3

This puts two years on the five-hour basis, and two years on the half unit basis. Such a course is, and can be administered, as is evidenced by the twenty or more public high schools of Greater New York.

I believe that the Commission has undertaken a good work, and it is in appreciation of this that I have given the matter some attention. I wish their report to be a credit to the educational sentiment of Michigan. As it now stands, I feel that it contains little or nothing, as far as the course in mathematics is concerned, which will be suggestive or helpful to any high school in the state.

SOME GENERALIZATIONS FROM THE ELEMENTARY GEOMETRY BY MEANS OF CENTRAL PROJECTION.

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In the study of advanced geometry, it is found that, by the introduction of certain new or more general ideas, the theorems of the plane geometry as ordinarily developed are but special cases of more general theorems. We readily understand the value of any point of view or method of treatment by which generalized theorems may be obtained, and especially if they can be obtained out of the special theorems themselves. One such method is found in the Projective Geometry. In the following paper, I propose to develop enough of this subject to make a few generalizations of some of the most elementary theorems; and also call attention to a few of the ideas which are of great importance in the modern geometry and which can be readily brought forward in this connection. We shall confine ourselves to relations between plane figures, although we shall find it necessary to make use of certain simple properties of the geometry of three dimensions.

Some of the general characteristics of the relations to be considered by us here are familiar enough to us from our common experience with shadows on the walls obtained by holding some object before a lamp or other source of light, and are readily obtained by comparing the figure held up with the resulting shadow. Of course, this is only a rough approximation, but it will give a very good idea of the character of the relations which we are to consider.

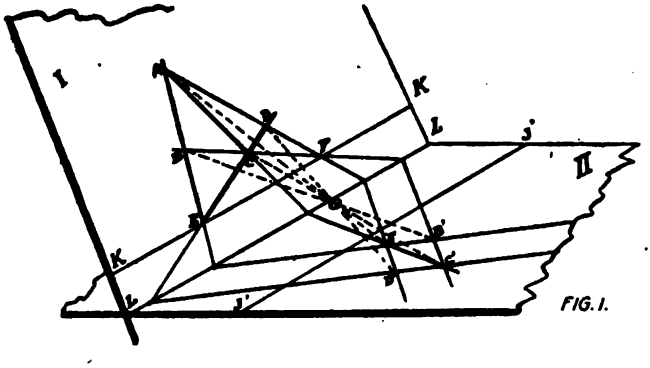


FIG. 1.

For the purpose of mathematical study, we reduce to ideal conditions as follows: Consider that two planes are given, one of which is called the *original plane* and the other the *plane of images.* The correspondence between the points of the two planes is such that if pairs of corresponding points be taken, the straight lines joining every such pair always passes

through a certain fixed point not in either of the planes, just as the point in the shadow and the point on the original object, in case before cited. lie on a line through the source of light. In this case the image is said to be obtained from the original object by Central Projection, and the fixed point common to all the lines joining corresponding points is called the Center of Projection. As you may readily see by examining the preceding figure.

From this it follows that only one point on the plane of images corresponds to a point on the original plane and conversely. Also if a series of points on one plane lie in a straight line, the corresponding points of the other plane also lie on a straight line, which is the intersection of the plane of images with the plane through the center of projection and the line in the original plane. Further, if a point describes a curve in the one plane, the corresponding point will describe a curve in the other; this curve is the intersection of the second plane with the conical surface generated by the straight line through the center of projection, O, and the moving point. Then, to a secant to a curve will correspond a secant to its image, and to a tangent to any curve will correspond a tangent to its image.

If we examine our figure more closely, we find that straight lines through a point project into straight lines through a point. Calling I the original plane, we notice that there seems to be an exception when the common point of intersection lies on K K, where K K is the intersection of the plane through the center of projection parallel to the plane II. In this case the lines become parallel, as is indicated in the figure, taking E as the point of intersection. A B E and D C E become A′ B′ and D′ C′ respectively. In this case we say that the point E is projected into a point of II, which is at an infinite distance. In a similar way the points of I at an infinite distance are projected into J′ J′. This we can restate as follows: *All lines of I which pass through the same point on K K are projected into a set of parallel lines on II; and any set of parallel lines of I projects into a set of lines of II which intersect J′ J′ in the same point.* It is evident that every point of L L projects into itself.

Let us now consider the figure made up of the four points A B C D of I, and the straight lines A B, B C, C D, D A passing through them. These form a general quadrilateral. We will now prove the following property:

By a proper choice of the center of projection and image plane, any given quadrilateral can be projected into a parallelogram; and inversely any given parallelogram projects into a non-special quadrilateral, in general.

Let A B C D of plane I be the quadrilateral, and E and F the points of intersection of the opposite sides. Now choose as image plane II, one parallel to the line E F and for center of projection O, any point in the plane through E F parallel to II. We see immediately that projection of the quadrulateral is a parallelogram, and the first part of our statement is proved.

For the second part of our statement we may begin with II as the original plane. Then choosing O as entirely arbitrary, we find that at least one pair of the parallel lines project into non-parallel lines, while in general the projections of both pairs will be non-parallel.

Before turning to the generalization of theorems, we must introduce a few definitions and the fundamental property of Projective Geometry.

Definitions:

1°. If a set of points lies on a straight line, they are said to form a range of points on that line.

2°. If a set of lines all pass through the same point, they are said to form a pencil of rays through that point as center.

3°. The anharmonic, or double, ratio of a range of four points A B C D is

$$\frac{AC}{BC} : \frac{AD}{BD}$$

and is represented by (A B C D).

In this expression we must take into consideration the directions or signs of the segments, remembering that the segment lettered A B, for example, may be considered as described by a point moving from A to B; and therefore that A B = —B A. This leads us directly to the result, that if A B C are any three points of a straight line, then A B + B C = A C, whether B lies within the segment A C or not.

4°. When (A B C D) = —1, the four points are said to be harmonically related or the four points are said to divide the line harmonically.

We will now prove the fundamental property of Central Projection, namely:

The anharmonic ratio of any range of four points is unchanged by projection, i. e.,

$$(A\,B\,C\,D) = (A'\,B'\,C'\,D')$$

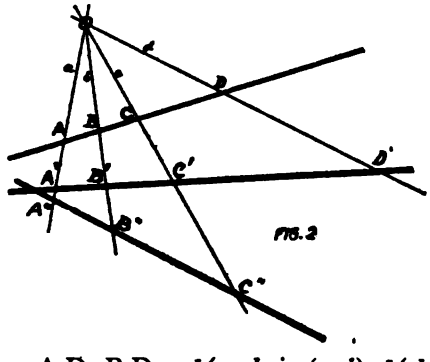


FIG. 2

Call a, b, c, d the lengths of the rays from O to A, B, C, D respectively, and designate the angle between a and b by $(a\,b)$, including sign as in the rectilinear segments above.

Considering the triangles O A C and O B C, we have

$$AC : BC = \tfrac{1}{2}\,a\,c\,\sin(a\,c) : \tfrac{1}{2}\,b\,c\,\sin(b\,c) = a\,\sin a\,c : b\,\sin(b\,c).$$

Similarly from the triangles O A D and O B D.

$$AD : BD = \tfrac{1}{2}\,a\,d\,\sin(a\,d) : \tfrac{1}{2}\,b\,d\,\sin(b\,d) = a\,\sin(a\,d) : b\,\sin(b\,d),$$

whence

$$(A\,B\,C\,D) = \frac{\sin(a\,c)}{\sin(b\,c)} : \frac{\sin(a\,d)}{\sin(b\,d)}$$

By the same method we find the same expression for (A' B' C' D'), and therefore

$$(A\,B\,C\,D) = (A'\,B'\,C'\,D').$$

It seems that possibly an exception might occur when the straight line on which we project is parallel to one of the rays. It is readily shown that the relation is still true under these circumstances, as follows:

Take the case where the straight line is parallel to d, then D″ is at an infinite distance.

If we consider the ratio A D : B D, it can be written A B + B D : B D = 1 + A B : B D. When D is at an infinite distance this ratio becomes unity. Therefore

$$(A'' B'' C'' D'') = A'' C'' : B'' C''$$

By considering the triangles O A″ C″ and O B″ C″, we have

$$A'' B'' : b'' = \sin (a\ b) : \sin (O A'' B'') \text{ and}$$
$$B'' C'' : b'' = \sin (b\ c) : \sin (O B'' C'')$$

From the Figure 2, we see that $\sin (O A'' B'') = \sin (a\ d)$ and $\sin (O B'' C'') = \sin (b\ d)$. By substituting these values we have the result

$$(A'' B'' C'' D'') = \frac{\sin (a\ c)}{\sin (b\ c)} : \frac{\sin (a\ d)}{\sin (b\ d)} = (A B C D),$$

as before.

We can consider the double-ratio $\frac{\sin (a\ c)}{\sin (b\ c)} : \frac{\sin (a\ d)}{\sin (b\ d)}$ as a double-ratio belonging to the pencil of four rays, and represent it by $(a\ b\ c\ d)$. Then in a manner similar to the above we can prove that it is unchanged by projection.

In Figure 2, we then have

$$(A B C D) = (a\ b\ c\ d), \text{ or}$$

The anharmonic ratio of a range of four points equals the anharmonic ratio of any pencil of four rays passing through them; and, the anharmonic ratio of a pencil of four rays equals the anharmonic ratio of any range of four points which lie on them.

It is well to call attention at this place to the reciprocal relation between the point and the straight line, which has appeared in our discussion, and to which we shall recur several times in our later development, particularly from the point of view that either may be readily considered as the fundamental space element. The point is the space element ordinarily used in the development of the elementary geometry. This idea of considering the space element as being other than a point has been one of very great importance in the modern development of geometrical investigation.

We will now call attention to a few common reciprocal forms of statement, i. e., those in which the word point is replaced by the word line and the word line by the word point, with only such other changes as may be necessary to make the form of statement correspond.

Points on a straight line, or range of points.

A straight line is the join of two points, or

A straight line is determined by two points.

A curve is a locus described by a moving point.

Straight lines through a point or pencil of rays.

A point is the intersection (join) of two straight lines, or

A point is determined by two straight lines (not parallel).

A curve is the envelope of a moving straight line.

A triangle is a self-reciprocal figure, that is, it may be considered as determined by three points or by three straight lines.

From these considerations we see that the relations between the anharmonic ratios of ranges and pencils stated above are reciprocal to each other. These examples will perhaps suffice to make the idea of the existence of a reciprocal relation in plane geometry seem plausible at least.

My first step in generalization will be to derive a theorem for a general quadrilateral from one for the parallelogram.

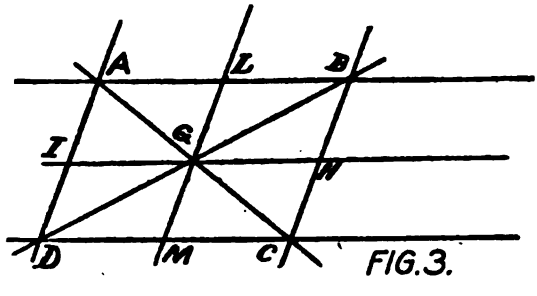


FIG. 3.

Consider the parallelogram A B C D. Through G, the intersection of its diagonals, draw G H and G L parallel to the sides A B and A D respectively. Then H and I bisect the segments B C and A D respectively. Call F the point at an infinite distance on A D, L M and B C. Recalling a result of our previous discussion, we have

$(A\,D\,I\,F) = -1$ since

$$\frac{AI}{DI}\,\frac{AF}{DF} = \frac{AI}{DI} = -1;$$

and a similar result for each of the other three sides of the parallelogram.

Since any quadrilateral can be projected into a parallelogram, this result must be true for any quadrilateral whatever. For if we project so that the pencils through F and E each becomes a set of parallel lines, we have the case of the parallelogram just discussed. Therefore in the quadrilateral A B C D,

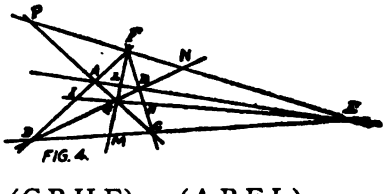


FIG. 4.

$$(A\,D\,I\,F) = -1 = (L\,M\,G\,F) = (C\,B\,H\,F) = (A\,B\,E\,L)$$

Also since the pencil of four rays at E is harmonic,

$$(B\,D\,G\,N) = (A\,C\,G\,P) = -1.$$

We may now state the first part of our result in the following form:

If a line be drawn from the intersection of two opposite sides of a quadrilateral to the intersection of the diagonals, either of the two remaining sides is divided harmonically by its intersection with this line, its intersection with the fourth side and the two vertices on it.

Also, for the second part,

If a line be drawn from the intersection of two opposite sides to the intersection of the diagonals, it is divided harmonically by these two points and its intersections with the remaining pair of opposite sides.

If we call the six intersections of the sides of the quadrilateral (as a four-sided figure) the vertices, and those vertices which do not lie on the same side, *opposite vertices,* as A and C, B and D, E and F respectively, and the lines through two opposite vertices by the name diagonals, as A C, B D and E F, the second part can be restated as follows:

Any diagonal is divided harmonically by the two vertices on it and its intersections with the other two diagonals.

We could easily find further harmonic properties, particularly of pencils, as of those with centers at E, F, G, but we will turn to a result which does not involve lengths but which is purely descriptive in its nature.

From the parallelogram, we know that L H, A C and I M are parallel; then in the quadrilateral we must have the result *that L H, A C and I M must all pass through a same point P on E F or all be parallel to it,* and a similar result for the three other lines I L, D B and M H, obtained in a similar way.

We have thus found two theorems for the general quadrilateral, one containing lengths, the other entirely descriptive, out of two very elementary properties of a parallelogram.

Now take Figure 4, omit the lines F G and E G and the points H, I, L, M determined by them, and construct a new figure in which lines take the places of points and points those of lines in the preceding. We obtain Figure 5, which is called the reciprocal figure of Figure 4; a, b, c, d, e, f are six lines joining four fundamental points of the four-point, and g corresponds to G of Figure 4.

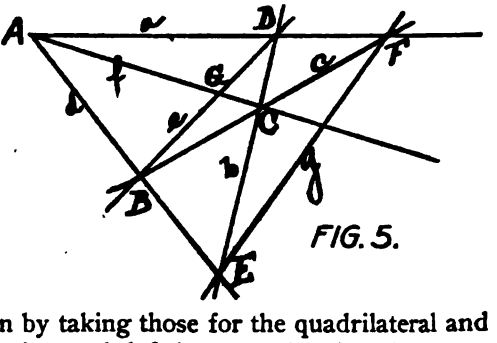


FIG. 5.

We can immediately state new theorems for this configuration by taking those for the quadrilateral and interchanging the words line and point, and defining opposite sides in a way entirely analogous to that for opposite vertices in the preceding.

The following theorem is obtained from that for the quadrilateral of Figure 4 by this method. It can be easily proved by methods already used for the harmonic division of a diagonal.

The pencil of four rays formed by two opposite sides and the lines joining their point of intersection to the two intersections of the remaining pairs of opposite sides is harmonic.

If we letter the intersections in Figure 5, as indicated, we notice that we have a self-reciprocal figure made up of seven lines and seven points, where corresponding lines and points have the same letter.

We will now turn to some further considerations of a similar kind connected with a circle instead of with a rectilinear figure.

Take any four points A, B, C, D on a circle and join them to any two-fifth points P and P', also on the circle. We know from the properties of the circle that the angle between the pair of rays joining any two points to P is equal or supplementary to the angle between the two rays joining the same points to P'. In either case, we know that the anharmonic ratio is the same for the two pencils. Now project on a second plane from any point. The resulting figure gives a conic section instead of a circle, and two pencils of four rays with their centers on the conic section and the rays intersecting in pairs, on the conic section, one ray of every pair from each pencil. This suggests the following theorem:

If any four fixed points of a conic section be joined to any fifth point on that conic section by straight lines, the anharmonic ratio of the pencil of four rays is constant.

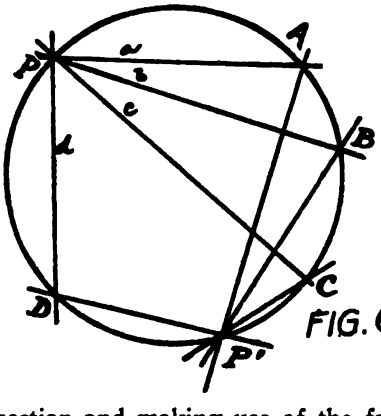


FIG. 6.

This can also be stated as follows:

If in two pencils (each having an infinite number of rays) corresponding rays are determined as those which intersect on a fixed conic section through the two centers of the pencils, then the anharmonic ratios of any two pencils of four corresponding rays are equal.

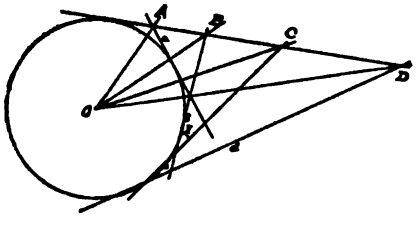
The proof of this could be obtained by using the reverse process of that stated above, beginning with the conic section and making use of the fact that any conic section can be laid upon some cone of revolution.

Turning now to the reciprocal theorem to that previously stated for the circle, using the circle again as basis, we have

If any four fixed tangents to a circle are cut by any fifth tangent, the anharmonic ratio of the four points of intersection is constant.

We will now prove this:

Join the O, the center of the circle to A, B, C, D, the points of intersection of the four tangents with the fifth. We will now prove that the angle between any pair of rays as O B and O C takes a certain value or its supplementary value, and is therefore otherwise independent of the position of the tangent A B C D.



Designating the angle between the

tangents b and c as indicated in the figure by I, we have the following equations:

$$\angle I + 2\ \angle BCO + 2\ \angle CBO = 360°, \quad \angle BOC + \angle BCO + \angle CBO = 180°$$
$$\therefore\ 2\ \angle BOC = \angle I \quad \text{or} \quad \angle BOC = \tfrac{1}{2}\angle I$$

The positions for which ∠ BOC would be the supplement of the above are readily seen to lie between parallelism to b and to c.

We see that a similar set of relations is true for all the pairs of lines O A, O B, O C and O D. Then the anharmonic ratio (A B C D) equals the anharmonic ratio of the pencil (O — A B C D), and as this is unchanged by the change of the position of the tangent our theorem is proved.

Now project. The circle becomes a conic section, the tangents become tangents to this conic section. Our theorem becomes the following:

If any four fixed tangents to a conic section be drawn, the anhormonic ratio of the four points of intersection with any fifth tangent to that conic section is constant.

Or again in somewhat different form:

If in two ranges (each having an infinite number of points), the corresponding points are determined by the fact that the straight line joining them is always tangent to the same conic section tangent to the two given straight lines, then the anharmonic ratios of any two ranges of corresponding four points is constant.

These two theorems suggest their converses, both of which are true but neither of them can be proved without further developments. However, I shall state both of them.

If two pencils of rays mutually correspond so that the anharmonic ratio of any pencil of four rays of one equals the anharmonic ratio of the pencil of four corresponding rays of the other, then the corresponding rays of the two pencils intersect on a conic section which passes through the centers of the two pencils.

And its reciprocal is:

If in two ranges of points, the points mutually correspond so that the anharmonic ratio of any set of four points of one equals the anharmonic ratio of the four corresponding points of the other, the lines joining the corresponding points will touch a conic section which is tangent to the two straight lines of the two ranges.

GERMAN SECTION

THE REPORT OF THE COMMITTEE OF THE GERMAN SECTION OF THE SCHOOLMASTERS' CLUB ON A UNIFORM HIGH SCHOOL COURSE IN GERMAN

The report of the Committee cannot enter upon a discussion of the difficult and perplexing question of the various methods of instruction to be followed in the study of German in the High Schools. This question is so intimately connected with the various grades and kinds of preparation of our teachers of German that no one method can for the present be dogmatically urged. Naturally the American teacher of German will at present be limited to such method or methods as his preparation, training and experience will permit. It is, however, the conviction of the Committee that the spoken language be used as far as possible in the class room and that this be more especially aimed at with students who take four years of German in the High School. The ideal of enabling the student eventually to read German literature in German without translating should be ever before the teacher. The Committee has therefore restricted itself in its recommendations to the amount and character of the work to be done in German each year in the High School. In order to give more specific help and guidance to the teachers of German in this State the Committee has thought it wise to indicate in this report the best grammars, readers, composition books and editions of texts to be used in the High Schools. In regard to the choice of texts the Committee was guided by the principle that only standard modern authors of approved literary excellence should be read, authors who are generally acknowledged by the German people as the soundest interpreters of German life and ideals. Modern German literature is so rich in novelistic, dramatic, historical and lyrical productions of a high order that even for the more elementary classes good literary selections may be found well suited to the age and preparation of High School students. If this principle be strictly observed, the instruction of German will gain enormously in dignity and interest and will greatly extend the range of knowledge and the culture of the student.

FIRST YEAR.

1. Thorough drill in German pronunciation and reading, to be continued through the whole course, whether it extend over two, three or four years.

2. A careful study of the elements of German Grammar—as presented in the First Part of Thomas's Grammar (Holt & Co., New York), pp. 1-175, or in the first thirty-five lessons of Joynes-Meissner's Grammar (Heath & Co., Boston). Keller's First Year in German (American Book Co., New York), Vos's Essentials of German (Holt & Co.), or Spanhoofd's Elementary German (Heath & Co.), practically cover the same ground.

3. Frequent translations of simple English sentences into German to fix the grammatical principles under consideration.

4. The reading of about 100 pages of well graded texts in a reader. The reader chosen should contain interesting selections, written in good modern German, and dealing, as far as possible, with typical phases of German life and literature. A reader like "Glück Auf" (Ginn & Co.), would in extent and character well answer this purpose. Guerber's Märchen und Erzählungen (Heath & Co.) might be substituted.

5. Easy German conversation and composition based upon the selections read.

SUGGESTIONS.—It is very desirable that German script be taught at the beginning of the year and used throughout the whole course. It is advisable that work in reading be introduced early, perhaps after the first six weeks of grammatical instruction.

SECOND YEAR.

1. A thorough review of the elements of German Grammar studied in the first year.

2. Composition. Translation from English into German. For this purpose Harris's (Heath & Co.), Wesselhoeft's (Heath & Co.), or Bernhardt's (Ginn & Co.) German Compositions may be used.

3. The reading of about 200-250 pages of standard literature in the form of short stories, dramas and lyrics. The literature might be selected from the following list:

Storm: "Immensee." Ginn & Co., Holt & Co., Heath & Co., George Wahr, Ann Arbor, Allyn & Bacon, Boston.
Heyse: "L'Arrabbiata." Heath & Co., Holt & Co., George Wahr.
Heyse: "Das Mädchen von Treppi." Holt & Co.
Storm: "Geschichten aus der Tonne." Ginn & Co.
Auerbach: "Brigitta." Ginn & Co.
Seidel: "Leiberecht Hühnchen." Heath & Co., American Book Co.
Zschokke: "Der Zerbrochene Krug." American Book Co., Holt & Co.
Keller: "Legenden." Heath & Co.
Baumbach: "Waldnovellen." Heath & Co.
Fulda: "Unter Vier Augen." Holt & Co.
Benedix: "Der Prozess." Holt & Co.
Wildenbruch: "Der Letzte." Heath & Co.
Rosegger: "Die Waldheimat." Ginn & Co.
A few lyrical selections from: "Deutsche Gedichte." Edited by Hermann Müller, Ginn & Co., or from Hatfield's edition of "German Lyrics and Ballads," Heath & Co., or from Dillard's "Aus dem deutschen Dichterwald," American Book Co.

A good selection would be: "Immensee," "L'Arrabbiata," "Leberecht Hühnchen," Keller's "Legenden," Baumbach's "Waldnovellen," "Unter Vier Augen," "Der Prozess," and a few lyrics.

Some High Schools which provide for only two years of German have

been in the habit of reading a classic drama during the second semester of the second year in order to give to the students some suggestion of the meaning of German classic literature. The practice, though laudable, is in many cases of doubtful pedagogical value, as the student at that stage has hardly attained sufficient knowledge of the language to read with intelligent appreciation a German classic. However, the progress of classes varies, and many teachers stoutly assert that the experiment has been successful. It is the opinion of the Committee that if a classic be read at the end of a two years' course, the most suitable selection is Wilhelm Tell or Minna von Barnhelm.

4. Conversation and composition on the works read.

THIRD YEAR.

1. A review of the elements of German Grammar and a careful study of German Syntax as presented in Von Jagemann's German Syntax (Holt & Co.), or in the Second Part of Thomas's or Joynes-Meissner's Grammars.

2. German Composition. Translation from English into German (Von Jagemann's or Poll's Composition, Holt & Co.), and paraphrases, abstracts or essays on the matter read.

3. The reading of about 400-450 pages of moderately difficult prose and poetry. The works might be selected from the following list:

Dramas.

Schiller: "Wilhelm Tell" (Holt & Co., The Macmillan Co., New York, Heath & Co., and Oxford University Press); "Jungfrau v. Orleans" (Holt & Co., Heath & Co., Macmillan).
Lessing: "Minna v. Barnhelm" (Macmillan, Holt & Co., Heath & Co.).
Freytag: "Die Journalisten" (Holt & Co., George Wahr).
Moser: "Der Bibliothekar" (American Book Co.).

Historical Prose.

Hoffmann: "Historische Erzählungen" (Heath & Co.).
Freytag: "Karl der Grosse" (Holt & Co.); "Doktor Luther" (Ginn & Co.); "Aus dem Staate Friedrichs des Grossen" (Heath & Co.); "Aus dem Jahrhundert des Grossen Krieges" (Heath & Co.).

Novelistic Prose.

Eichendorff: "Aus dem Leben eines Taugenichts" (Heath & Co.).
Ebner-Eschenbach: "Freiherren von Gemperlein" (Heath & Co.).
Fouqué: "Undine" (Holt & Co., American Book Co.).
Freytag: Abbreviated edition of "Soll und Haben" (Ginn & Co.); "Der Rittmeister von Alt-Rosen (Heath & Co.).
Hauff: "Lichtenstein" (Heath & Co.).
Riehl: "Der Fluch der Schönheit" (Heath & Co.).
Rosegger: "Die Schriften des Waldschulmeisters" (Ginn & Co.).
Wildenbruch: "Das edle Blut" (Heath & Co., American Book Co.).

Lyrics and Epics.

A few selections from the lyric poetry of Goethe, Schiller, Heine and Uhland, etc. Hatfield's "German Lyrics and Ballads" (Heath & Co.).
Scheffel: "Der Trompeter von Säkkingen" (Heath & Co.).
Schiller: "Das Lied von der Glocke" (Heath & Co.).

General literary interpretation should be aimed at.

4. Conversation and Composition on the works read.

FOURTH YEAR.

1. Grammar and Syntax reviewed. (Von Jagemann's German Syntax).

2. Composition. Translation from English into German (Von Jagemann or Poll's Composition), and German abstracts and free German essays on the works read.

3. The reading of about 500 pages of standard German literature with aim at general literary interpretation. The lives of several of the great German poets should be read. The following biographies might be used for this purpose:

Lessing: Rolleston. Great Writers Series, London.
Schiller: Nevinson. Great Writers Series.
Goethe: Sime. Great Writers Series.
Heine: Sharp. Great Writers Series.
Uhland: Hewett. Introduction to Hewett's edition of Uhland's Poems. (Macmillan & Co.).

The works read might be selected from the following list:

Dramas.

Goethe: "Egmont" (Ginn & Co., Holt & Co., Macmillan); "Iphigenie" (Macmillan, Heath & Co.).
Schiller: "Jungfrau v. Orleans" (Holt & Co., Macmillan, Heath & Co.), [if not read in the third year]; "Maria Stuart" (Macmillan, Scott, Foreman & Co., Heath & Co.).
Lessing: "Minna v. Barnhelm" (Macmillan, Holt & Co., Heath & Co.) [if not read in the third year]; "Emilia Galotti" (Ginn & Co., Heath & Co.).
Heinrich v. Kleist: "Der Prinz v. Homburg" (Ginn & Co.).
Grillparzer: "Sappho" (Ginn & Co.); "Der Traum ein Leben" (Heath & Co.).
Fulda: "Der Talisman" (Heath & Co.).

Novelistic Prose.

Freytag: "Die Verlorene Handschrift" (Macmillan).
Goethe: "Sesenheim" (Heath & Co.).
Heine: Prose Selections (Macmillan, Clarendon Press).
Keller: "Dietegen" (Ginn & Co.); "Romeo und Julie auf dem Dorfe" (Heath & Co.).
Kleist: "Michael Kohlhaas" (Holt & Co.).

Kleist, Zschokke and Goethe: "Three German Tales" (Holt & Co.).
K. F. Meyer: "Gustav Adolfs Page" (Heath & Co.).
Scheffel: "Ekkehard." Abbreviated edition (Heath & Co.).

Historical Prose.

German Historical Prose: Ranke, Droysen, v. Treitschke, v. Sybel (Holt & Co.).
Schiller: "Der dreissigjährige Krieg" (Holt & Co.).
Von Sybel: "Die Erhebung Europas" (Ginn & Co.).

Epics and Lyrics.

Goethe: "Hermann und Dorothea" (Macmillan, Heath & Co.).
Goethe's Poems (Holt & Co., Heath & Co.).
Heine's Poems (Heath & Co.).
Uhland's Poems (Macmillan & Co.).

4. Conversation and Composition on the works read.

MAX WINKLER, Chairman,
University of Michigan.
HELENE CHRIST,
Grand Rapids High School.
TOBIAS DIEKHOFF,
University of Michigan.
HOWARD EDWARDS,
Michigan Agricultural College.
R. CLYDE FORD,
Michigan Normal College.

SUGGESTIONS FOR A SMALL GERMAN HIGH SCHOOL LIBRARY

A. CLASSICS.

Selected volumes of the works of GOETHE, SCHILLER, LESSING, in Kürschner's "Deutsche National-Literatur," about 75 cents a volume.
GOETHE, volumes 1–21.
SCHILLER, volumes 1–7, 10–12.
LESSING, volumes 1–3, 7, 9, 10, 12.
VON KLEIST, H., volumes 1–4.
HEINE, edited by Elster, 7 volumes, Bibliogr. Institut. $4.00
UHLAND, Poems. The Macmillan Co., 60 cents.

B. BIOGRAPHIES.

The lives of GOETHE, SCHILLER, LESSING, HEINE, in the "Great Writers Series," edited by Professor Eric Robertson. 40 cents a volume.
HERM. GRIMM: "Life and Times of Goethe," translated by S. H. Adams. Little, Brown & Co. $2.50.

HEINEMANN, K.: "Goethe." Two volumes. Leipzig, E. A. Seemann. $3.00.
THOMAS, C.: "Life and Works of Schiller." Holt & Co. $1.50.
SIME: "Lessing." Two volumes. London, 1890. $4.00.

C. HISTORIES OF LITERATURE.

W. SCHERER: "History of German Literature." Scribners. $3.00.
VOGT UND KOCH: "Geschichte der deutschen Literatur." Leipzig. Bibliogr. Inst. $4.00.
K. FRANCKE: "History of German Literature." Holt & Co. $2.50:
JOHN ROBERTSON: "History of German Literature." Putnam. $3.25.

D. DICTIONARIES.

MURET-SANDERS: "English-German and German-English Dictionary." Two volumes. School edition. Berlin. Langenscheidt. $4.00.
FLUEGEL'S "English-German and German-English Dictionary." Two volumes. Leipzig. Brockhaus. $4.25.
HEATH'S "New German Dictionary." $1.20.
H. PAUL: "Deutsches Wörterbuch." Halle. Niemeyer. $2.50.
DUDEN: "Orthographisches Wörterbuch" (large edition). Leipzig. Bibliogr. Institut. 40 cents.
SANDERS: "Wörterbuch der Haupt-Schwierigkeiten." Berlin. Langenscheidt. $1.10.
MATTHIAS: "Katechismus des guten Deutsch." Leipzig. Hesse. 50 cents.
F. KLUGE: "Etymologisches Wörterbuch." Strassburg. Trübner. $3.00.

E. GRAMMARS.

THOMAS: "German Grammar." Holt & Co. $1.12.
JOYNES-MEISSNER: "German Grammar." Heath & Co. $1.12.
WHITNEY: "German Grammar." Holt & Co. $1.50.
BRANDT: "German Grammar." Putnam. $1.25.
BIERWIRTH: "German Grammar." Holt & Co. $1.25.
HEMPL: "Orthography and Phonology." Ginn & Co. $2.00.
VON JAGEMANN: "German Syntax." Holt & Co. $1.00.
WEISE: "Unsere Muttersprache." Leipzig. Trübner. $1.00.

F.—NOVELS.

G. FREYTAG: "Soll und Haben." Leipzig. Hirzel. $1.75.
V. VON SCHEFFEL: "Ekkehard." Stuttgart. Bonn. $1.50.
SPIELHAGEN: "Problematische Naturen." Leipzig. Staackmann. $2.00.
KELLER: "Die Leute von Seldwyla." Berlin. Hertz. $2.00. "Züricher Novellen." Berlin. Hertz. $1.00.
IMMERMANN: "Der Oberhof." Stuttgart. Speemann. 25 cents.
C. F. MEYER: "Jürg Jenatsch." Leipzig. Haessel. $1.25. "Novellen." Two volumes; each $1.25. Leipzig. Haessel.
HEYSE: "Novellen" (Auswahl für Haus). Berlin. Hertz. $2.50.

STORM: "Immensee." Braunschweig. Westermann. 50 cents. "Aquis Submersus." Westermann. $1.25.

ROSEGGER: "Schriften des Waldschulmeisters." Wien. Hartleben. 90 cents. "Waldheimat." Two volumes. Hartleben. $1.80.

G. HISTORIES OF GERMANY, ETC.

HENDERSON: "History of Germany." Macmillan. $4.00.

HANS MEYER: "Das Deutsche Volkstum." Leipzig. Bibliogr. Inst. $4.00.

ZEHME: "Kulturverhältnisse des deutschen Mittelalters." Leipzig. Freytag u. Tempsky. 50 cents.

PUTZGER: "Historischer Schulatlas." Leipzig. Velhagen u. Klasing. 60 cents.

H. MISCELLANEOUS WORKS.

SCHOENBACH: "Über Lesen und Bildung." Graz. Leuschner. $1.25.

ECKERMANN: "Gespräche mit Goethe." Stuttgart. Cotta. 75 cents.

GOETHE-SCHILLER: "Briefwechsel." Stuttgart. Cotta. 50 cents.

NIBELUNGENLIED (Übersetzt von Simrock). Stuttgart. Cotta. $1.50.

BRUEDER GRIMM: "Märchen." (Large edition). Berlin. Hertz. $1.00.

O. FRICK: "Wegweiser durch die Klassischen Schuldramen." Four volumes. Leipzig. Hofmann. $6.00.

This list of books for a small German High School Library has been prepared by the members of the German Department of the University of Michigan at the request of the German Section of the Schoolmasters' Club of the State of Michigan. The schools are advised, as far as possible, to import the German books of this list directly from Germany, and for their guidance the following German firms are suggested: Bernhard Liebisch, Leipzig, Kurprinzstr. 6; Mayer und Müller, Berlin N. W., Prinz Louis Ferdinandstr. 2; F. A. Brockhaus, Leipzig, Querstr. 16.

It may also be stated that Mr. Gustav Stechert, 9 East 16th St., New York City, is willing to import the German books of this list at the rate of 22 cents for the mark.

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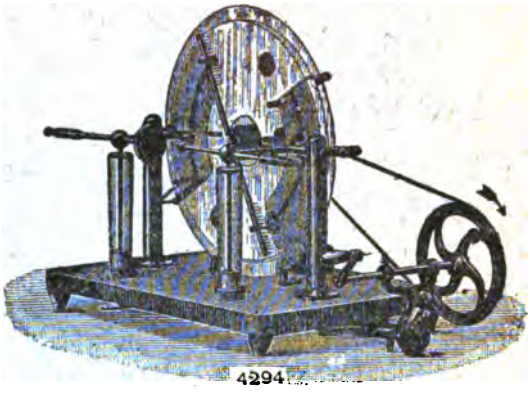

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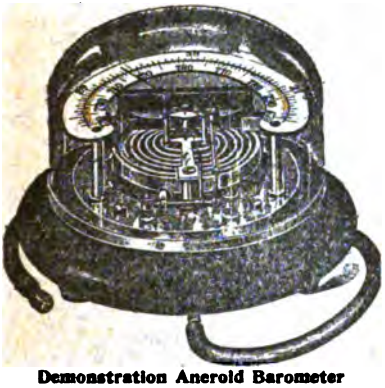

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Michigan Schoolmasters' Club

PROCEEDINGS OF THE FORTIETH MEETING, HELD AT ANN ARBOR, MARCH 30, 31, APRIL 1, 1905

EDITED BY THE SECRETARY

GENERAL MEETINGS

The fortieth meeting of the Michigan Schoolmasters' Club began on Thursday, March 30, with meetings of the classical, modern languages, and physics and chemistry conferences. The general meetings were held on Friday and Saturday mornings, March 31 and April 1. So large was the attendance that the meetings, for the first time in the history of the Club, were held in University Hall. Friday morning Professor R. M. Wenley, of the University, read a paper on "The Nature of Culture Studies." This paper was published in the *School Review*. Professor L. H. Bailey of Cornell spoke upon "The School of the Future," and Professor J. R. Angell of Chicago spoke upon the "Work in a Psychological Laboratory." Since Mr. Bailey and Mr. Angell spoke from notes, no papers could be obtained for publication.

On Friday at 4 P. M., in the Barbour Gymnasium, the Club attended a gymnastic entertainment given by the young women of the University. The exercises were in charge of Dr. Helen E. Brooks, assisted by Miss Bertha S. Stuart, and consisted of the usual class drills, closing with a basket ball game.

At 5 P. M., in University Hall, a musical recital was given by the Faculty of the University School of Music, under the direction of Professor A. A. Stanley. Numbers were given by A. A. Stanley, William Howland, Henri Ern and Albert Lockwood.

At 8 P. M., in University Hall, President Woodrow Wilson delivered one of the best addresses to which the Club ever listened. The subject, "The University and the Nation," was most appropriate, and showed Mr. Wilson at his best.

The papers read Saturday morning by Mr. W. H. Brett, of Cleveland, and Supt. S. O. Hartwell, of Kalamazoo, are printed in these proceedings.

That of Mr. E. L. Miller, of Chicago, on "The Greek in English," was published in the *School Review.*

The minutes of the business meeting and the program in full may be found immediately following the papers.

During the meetings music was furnished by the Faculty of the School of Music.

THE SCHOOL AND THE LIBRARY.

WILLIAM H. BRETT, LIBRARIAN CLEVELAND PUBLIC LIBRARY.

I am glad of the opportunity of being with you on this occasion, because it has given me the opportunity of meeting good friends I do not have the pleasure of seeing frequently, and it is especially gratifying to realize that this invitation comes to me not as a personal matter but as a recognition by you as teachers, of the library as an educational institution and one which is working for the same purposes you have in view.

The free public school is a full generation older than the free public library, and in this country a generation means much for progress. I can remember distinctly the account which my father gave me of the school which he attended in a little village in western New York. It was a square building with a door in one side and a table for the teacher. The benches on the floor, of slabs supported on pegs, and without any desks, were for the smaller children. The older ones who were writing and ciphering were provided for by a shelf, made also of a slab smooth side up supported against the wall, with similar benches in front of it. This school was supported by a subscription of those whose children attended. The thing which I remember most distinctly was my own surprise when I really grasped the idea for the first time that there had not always been such comfortable appointed school houses as those to which I was accustomed in my own native Ohio town.

Another picture which is among the most vivid in my memory is framed, so to speak, in the main school building of this same Western Reserve town. A three-story brick building on a city street, the first floor occupied by a grammar school, the second by the high school, and the third by the assembly room where Friday afternoon brought the dreadful ordeal of "speaking pieces;" a tow-headed boy who belonged in the first year of the high school seated on the steps leading up to the assembly room, furtively watching the door for the appearance of the principal, but unable to resist the temptation of following still further the fortunes of Ivanhoe. The tow-headed boy was myself, but the book I was reading was not a library book. I am quite sure that I really got more of history from the Waverly novels, and from Cooper, than I did from the text books; but my acquaintance with them

was made in small part from the few books which my good father was able to buy for me, it was made very much more from the kindness of "Good Samaritan" neighbors, and I think that as a boy I cultivated the acquaintance of most of the people in town who owned books.

I think that the surprise of my own children and the children who are growing up in these days will be scarcely less to realize that there was a time not so long ago when there were no free public libraries as my own was to think of the time when free public schools were not general.

The free public libraries of the United States had their beginning a little over fifty years ago and are largely a development of the last thirty years. The first free public library law was a special one for the city of Boston, passed in 1848, from which nothing seems to have been done. The first state library law was that of New Hampshire in 1849. Then followed the state law of Massachusetts in 1851, Maine in 1854, Vermont in 1865, Ohio in 1867. Since then similar laws have been enacted in most states of the Union.

The statistics show that there were in 1875 a little over 2,000 libraries having over 1,000 volumes each with a total of about 11,500,000 volumes. In 1885 there were 3,000 libraries with a total of 19,000,000 volumes; in 1890 3,500 libraries with about 26,000,000 volumes; in 1895, 4,000 libraries with 33,000,000 volumes; in 1900 over 5,000 libraries with over 44,000,000 volumes, while the report of the Commissioner of Education for 1903 gives 6,869 libraries with 54,500,000 volumes. The financial reports are evidently incomplete, but show as to endowments a total of over $25,000,000, and buildings to the value of over $47,000,000. The report as to income is also incomplete, but about one-third of the libraries report income aggregating a little less than $8,000,000. The progress since 1900 has been very rapid, and it is fair to assume that the financial gains have kept pace with the growth of libraries as given above. The report on books used in 1900 is probably also incomplete, but gives a total of over 58,000,000 books issued for home use.

While these figures are small as compared with 254,076 buildings for the accommodation of the common schools alone, with their property valued at $601,571,307, with their 439,596 teachers and 15,925,887 primary and grammar school pupils, as reported by the Commissioner of Education in his report for 1901-2, they will serve to give the libraries a place with the schools as a part of the educational equipment of the country.

With this great material growth of the library has come with equal step an advance in methods and an enlargement of its purpose. Cataloging and classification systems and interior library arrangements have been greatly improved. Greater freedom in the use of the library is permitted. Bibliographies, indexes, and other helps in the use of books have been devised so that the effectiveness of each book has been increased. By means of branch libraries, stations, traveling libraries, club work, home libraries for children and lectures, and other agencies, the library has become an effective educational force in the community rather than merely a depository of books.

Along with this has been developed within the last fifteen, very largely indeed within the last ten years, effective coöperation between the school and the library with the purpose of rendering the books useful to both teachers and pupils and, to some extent, to the families represented in the schools.

A very carefully conducted inquiry was made by the Librarian of the Dayton public library at the instance of the President of the American Library Association, the results of which were reported at the meeting of that association in St. Louis last October. A circular of inquiry was sent to 300 representative libraries, and responses were received from 218.

This inquiry elicited the facts both as to the work which Boards of Education are doing in supplying supplementary reading, and also the extent to which the public libraries are used by the schools. Many schools have collections, largely, however, of text books and supplementary reading. Fifteen cities supply 340,000 volumes of supplementary reading. One hundred thirty-four cities are reported as furnishing free supplementary readers, and in sixty of these class room libraries are also furnished by the library.

The report appears to be more full as to the use of books furnished by the public libraries. Twenty-five libraries furnishing class room libraries to schools aggregating 69,000 volumes, report a total annual circulation to public school pupils of 1,250,000 volumes. Thirty-three libraries report school deposit stations which are practically branch libraries for the neighborhood. Such collections vary from a few hundred to three or four thousand volumes, and are usually in schools at an inconvenient distance from other library resources. A case is reported where one such library of 30 volumes was read by nearly 500 people in three weeks. Seventy-two libraries report special collections of reference books for children. Fifty-six libraries supply catalogs and book lists on school subjects. Twenty-eight libraries have special assistants for children's reference rooms, and a much larger number report special rooms reserved for teachers and students and reservation of books for class use. The practice is almost universal in American libraries of issuing to teachers special cards on which a larger number of books may be drawn, and of giving them special privileges in other ways. The figures show clearly that in a great variety of cases and at a rapidly increasing rate provision is being made for the use of the books of the libraries by the teachers and pupils of the schools.

Another most important phase of the work, and a more recent one, is the development of plans for instruction in schools in the use of reference books, catalogs, bibliographies, and local library resources. Sixty-three libraries report such instruction. In thirty-five of these it takes the definite form of a regular course. Such courses have been given in twenty high schools and in a number of normal and grammar schools. Eight libraries offer courses to teachers and normal school students in children's literature.

I gather from the discussions at the library section of the National Educational Association that the necessity for this instruction in the use

of the library is being very generally recognized in normal schools. I observe accounts of such work from Kansas, California, Wisconsin, Minnesota, Pennsylvania, and New York. This indicates that the need of teaching the use of books is being recognized, and is one of the most hopeful indications of the whole situation. It is good to bring the child and the book together; the good will be greatly increased if the child is taught how to select the book and get what he wants from it most readily and certainly. In this I am discriminating clearly between the teaching of literature, which has so long been done in schools, and teaching how to use books, although the two go hand in hand. The value of this can hardly be estimated. It is important for the school work in hand, and even more so as a part of the equipment for the work of life, to be able to use books effectively, to reach promptly and certainly what is needed, and to estimate its value.

May I illustrate what I mean by a little account of what is done in one normal school with whose work I am somewhat familiar? For several years past the junior class has received instruction in the use of the library from one of its teachers. The course of instruction included the classification and arrangement of the library on the shelves; lists, catalog, and various bibliographies and indexes by which books are selected and found in the libraries with practice in their use; also the use of the volume itself when found; the value of what may be gleaned from the title page, chapter and page headings, marginal and other notes, the difference between the table of contents and the index; and other means by which one may judge of a book and reach what is wanted in it. It also includes the use of the fundamental reference books such as the general and special encyclopædias, dictionaries, bibliographies, indexes, gazeteers and atlases, with problems in reference work. The practice work includes the selection of books upon subjects proposed, discrimination as to the value, scope, and method of treatment in each, the writing of a brief synopsis and criticism of some one book selected from those first chosen, with reason for the selection. In history the students are taught to discriminate between source books, those which are valuable for general reading, and books for younger readers. These are fair specimens of the work which is carried on at various libraries. This is carried on parallel with the work in the school in literature. During the past two years this has been in the hands of a special teacher formerly a member of the staff of the public library, and is one of two courses given by her, the other being a course in the criticism and selection of books for children. The full result of such work will only be seen when the young women thus trained in the normal school become teachers of others.

The work thus far done has been in the main in the direction of supplying books in the schools as aids to the curriculum. The purpose with which the work was begun was to furnish supplementary reading books which would illustrate and add interest to the text book or other class work. With the development of the work, however, has come a greater recognition of its importance and a change of attitude towards it. We are beginning to see, in the words of Dr. Harris, that "The school is set at the task of teach-

ing the pupil how to use the library in the best manner—that, I take it, is the central object towards which our American school methods have been unconsciously guided."

The functions of the public library, in the new conceptions of its work, are to assist the school in its work for its pupils throughout school life, and further and still greater than this, to give to the whole community, including these same pupils when through with school, the opportunity of continuing their education throughout life.

The schools are for children and youth; the library for life. The correlative to such recognition of the library is the recognition on the part of the school that the use of books is not alone an auxilliary to the text book in the curriculum, but that the teaching of the right use of books is one of the most important purposes of the school; that it is not merely an adjunct, but an end. This changes fundamentally the attitude toward the library in and outside of the school.

The situation may be summed up as follows: For the past fifteen years or a little longer, but mainly within the last ten, there has been a growing use of the library by the schools, and efforts in various cases on the part of the library to become more useful to the schools; these two efforts have been marked by earnestness and sincerity on both sides, but have been tentative and various in methods and in effectiveness. The interest has extended very widely, and the total accomplishment has been considerable. The number of books placed at the disposal of the schools is a very large one. There have also been the valuable efforts noted to give instruction in the use of the library on the part of normal and high schools and libraries, but much less has been accomplished along this line. The significant thing, however, does not lie in what has been accomplished, but in the fact that the schools and libraries have found each other and are earnest and eager to work together. It remains now to devise the best methods for coöperation. This will take time, earnest effort, trial, failure, no doubt at times, but that it will be worked out successfully I do not question.

One promising method of bringing this about, and one which is in successful operation in various places, is the combination of the public library and the school library in the high school or larger grammar school building. A room convenient of access both from the interior and exterior of the building, well lighted and appointed, with a permanent reference collection for the use of the school and a deposit of books from the public library for the school and public use, the hours so arranged that the public use does not interfere with that of the school use, and by this combination of interest the library is made effective both to the school and the neighborhood at the least possible expense. Such plans are in operation in some high schools, and may well be extended to the larger grammar schools. If in addition to this a reading room may be opened, not for the idler over the daily papers, but supplying the better class of periodical literature, it would add to the value.

The open library, the reading room, provisions for the reading and

debating groups of the neighborhood, and other similar work, would go far to make the school of each district a social and civic center, would attach the people of the neighborhood to them, and give an interest which they cannot now have in them, standing as they do sombre, unlighted, and unused during the evening and holiday hours of the week. This has been done in some instances. I wish I had time to tell you of the good accomplished in one school in Chicago of which I happen to know by the efforts of one devoted woman. The desirable thing is to furnish the means, the opportunity in each of the school buildings for the use of books. A permanent collection of the fundamental reference books at least, and of such other books as are used so continuously and permanently, supplemented by deposits of books from the public library for temporary use. The whole to be kept in close and vital connection with the library so that the pupils may realize that it is a part of the library work and that the whole resources of the library are at their command, and that they may naturally pass along from the smaller to the larger library, and just as naturally continue the use of this after they leave school.

Such an arrangement would need the services of a teacher-librarian in each school, and would render more necessary the development of such instruction in the use of the books and of the library as that already outlined. Some instruction in the use of books might be given in the higher grammar grades, still more in the high school, and should certainly be amplified and more thoroughly extended in the normal school, for the pupil there will soon be teacher and use her knowledge of the methods of using books for the benefit of her pupils and will in turn impart to them. From these normal school graduates most apt for library work could be trained the teacher-librarian for the school libraries. While the value of such work in the school appears to me to be great, I realize that your opinion ought to be better than mine. From my point of view I can foresee great possibilities of increased usefulness for the library in this connection with the schools. I realize that such plans will take time and involve large experimentation. The library and the school will work together in this for the same end, and there should be no practical difficulties in arranging all the financial questions and administrative details involved. One of the forces in the direction of such coöperation is the library section of the National Educational Association. This was organized, as you all doubtless know, at the Buffalo meeting in 1896, and has met annually since. The department meetings have grown in numbers and interest annually. At the Detroit meeting in 1901 a very interesting paper was read by the librarian of the College of Education of Chicago on library instruction in normal schools. The sessions at the St. Louis meeting in 1904 were especially interesting and valuable. Although I have no doubt that the members of this club are very largely in attendance at the meetings of the National Educational Association, I can hardly hope that in the very many important general meetings which demand attention there these particular meetings can receive much attention from you. The fact, however, that such recognition is given to the library in the great

National Educational Association is an important one, and a similar recognition in the programs at the meetings of the various state meetings would go far to promote effective coöperation. Persistent, earnest work, by teachers and librarians with mutual respect and good will, and willingness to make concessions as to questions of expense and authority, will work out by degrees, whether along the lines I have suggested, or other still better, a greater, more effective and valuable use of books in schools, and beyond the school.

DISCUSSION.

H. O. SEVERANCE, UNIVERSITY OF MICHIGAN LIBRARY.

One of the main purposes of education is to teach pupils to read, to create in them the reading habit. The text-books form the basis of this work, but to accomplish the best results the teacher must secure help outside of the text-books. Supplementary reading in all the grades has added materially in bringing about the best results. One of the purposes of the school library is to furnish material which will supplement the text-books, not in reading alone but in other studies as well.

The libraries in most of the rural districts are small, and, possibly, it does not seem worth while to give them any attention. The same is true, but not to so large an extent, in the high schools where there is no public library. But teachers will find that by giving attention to these small and seemingly insignificant collections, they may be made to serve the best interests of the schools. A few of the best reference books, some fiction, stories of travel and adventure will help to interest the pupils in the school.

When these books are loaned out and are carried into the homes of the children, the parents read them, their attention is drawn towards the school and the teachers. While such libraries are primarily for the pupils, yet it is hoped that the parents also may be helped, and become interested in good books and in the school.

The first thing for teachers to do to make the library the most useful, is to classify the books in a simple way and familiarize themselves with the contents. If the library should contain several hundred volumes, then a card catalogue of the collection should be made which should include all authors, editors, and translators, titles and subjects. The fewer the books in a collection, the more minutely should the books be analyzed. Printed cards for most of the books can be had from the Library of Congress at the very small price of two cents apiece for the first card and one-fourth cent for each duplicate card.

One of the best guides for this work is the "A. L. A. Catalogue of Books," containing a list of 8,000 volumes. It is free to all libraries. Address, Librarian of Congress, Washington, D. C.

The book contains

1. The decimal and expansive systems of classification and the titles of 8,000 volumes arranged in classes. Also the same arranged as a dictionary catalogue.

2. Prices, publishers and dates of publication.

3. Call numbers for the Library of Congress cards. Some other books which would be useful are the manual put out by Miss G. M. Walton, librarian, Normal College, Ypsilanti; and Surrat's School Libraries, published as a bulletin of Baylor University, Waco, Texas.

Nothing will add more to the interest in the library than the addition of new books to the collection. This may be done in three ways:

1. By taking heed to secure all the money due the district from "fines for breach of the peace," which in many cases amounts to a considerable. Every school district is entitled to a share of the fines for the breach of the peace. Such fines are to be used for the purchase of books for the school districts and for no other purpose.

2. The proceeds of school entertainments and socials may add a considerable number of books to the library.

3. The school board may appropriate a small amount for the purchase of books.

Another means of securing fresh reading for schools libraries is to enter into relations with the State Library so that the traveling libraries may be sent to your library. Every school library in the State under certain conditions, may secure the loan of a traveling library of 50 volumes of well selected books, from the State Library. After the books in the first library have been read a second library may be had in the same way and so on.

Libraries may be had from the State Board of Library Commissioners by the registration system. Every library containing 100 volumes, by registering with the commission, may borrow 100 volumes from the secretary. These books may be kept six months. Then, if any books have been added to the library in the meantime, a loan of another 100 volumes may be secured.

By these means it is possible to secure 50 new booke four times per year at least, for the readers in every school district in the State.

If every district school teacher in the State would take the matter in hand, every child in the State would have a collection of good books accessibie to him at all times within an hour's walk.

DISCUSSION.

SUPERINTENDENT H. M. SLAUSON, ANN ARBOR.

Superintendent Slauson said that, in his opinion, the great problem is to get children to read the *right* books. Investigations into the amount of reading that school children are doing show that many are really reading more than they can possibly digest, the majority are reading enough and only a small proportion need to read more. It is the quality, not the quantity,

of school children's reading with whch we need to be concerned. Grown people are influenced to read new books by skillful advertising in the form of book reviews, by expressions of opinion from their friends and by judicious displays on open shelves in libraries and book stores. We cannot employ quite the same means for interesting children but we need to give just as much thought to our methods as do the publishers and the book dealers, that is, we must work on business methods.

Children should have books that are suited to their mental and moral stages of advancement. It is of little use to give a child a book that is far above either his mental or his moral stature; usually he will not read it, and, if he does, it is not at all likely to produce any beneficial effects. From a moral point of view, the best book for any child is the one that, judged by its morality, just measures up to the highest plane that he is capable of appreciating and that will make him capable of appreciating a better one, after reading it.

A librarian can do much through personal influence to guide the reading of the children of a community. Open shelves and a wise attendant may do what the book dealer does with grown people.

The teachers of the public schools have the best opportunity of all the agencies available. They may place lists of suitable books before the school children, may give credit for reading that the children may do under their direction, and may encourage home and vacation reading.

In Ann Arbor, the patrons of the public library are chiefly the school children. Twenty-seven per cent of them are in the high school, thirty-three per cent are in the grades, and the remaining forty per cent are adults. Of our high school enrollment seventy-four per cent are library patrons; of the grades, twenty-five per cent. If this is an unusually large proportion of school children as patrons, it may be due to the fact that the library has, for years, been situated in the high school building and, thus, the teachers have had unusually good opportunities for exerting the influence to which I have referred.

ATHLETICS IN MICHIGAN SECONDARY SCHOOLS.

SUPT. S. O. HARTWELL, KALAMAZOO.

The Committee on High School Athletics, to whom a revision of present athletic arrangements was entrusted at the State Association in December, 1904, made their report at the Schoolmasters' Club April 1st. The report was adopted and the new arrangements and revised rules go

into effect with the opening of the foot-ball season next fall. The main provisions are:

I. That the University Athletic Association, through the Inter-scholastic Manager, should keep the management:

(*a*) Of track and field athletics,

(*b*) Of the Thanksgiving Day game,

and that the Inter-scholastic Manager should also be responsible for securing officials when asked to do so by the Athletic Director.

II. That for forming a foot-ball schedule (and for base-ball if the sections should later so wish) the State should be divided into sections. The first division is the Upper Peninsula, which will make its own sections and schedules as hitherto. The second division or Lower Peninsula is divided into eight sections comprising the following counties:

LIST OF COUNTIES.

1. Lenawee, Livingston, Monroe, Oakland, Washtenaw, Wayne.
2. Branch, Calhoun, Eaton, Hillsdale, Ingham, Jackson.
3. Allegan, Barry, Berrien, Cass, Kalamazoo, St. Joseph, Van Buren.
4. Kent, Mecosta, Montcalm, Muskegon, Newaygo, Oceana, Ottawa.
5. Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Isabella, Midland, Saginaw, Shiawassee.
6. Huron, Lapeer, Macomb, Sanilac, St. Clair, Tuscola.
7. Alcona, Alpena, Arenac, Cheboygan, Crawford, Iosco, Montmorency, Ogemaw, Oscoda, Otsego, Preque Isle, Roscommon.
8. Antrim, Benzie, Charlevoix, Emmett, Grand Traverse, Kalkaska, Lake, Leelanau, Manistee, Mason, Missaukee, Osceola, Wexford.

III. In each section a committee has been appointed to secure the organization of the section with the co-operation of as many schools as possible before the close of this term. The schools in each section which agree to enter an athletic league and be governed by the rules which have been adopted by the High School Section of the State Teachers' Association, shall organize by selecting a committee of three, which committee will arrange schedules of athletic contests within the section, and act as a board of appeals on any disputes arising between schools in that section. Section contests must be completed so that a representative team for each section shall be selected by a date to be mentioned by the Athletic Director, which date for the fall foot-ball schedule this year will be November 6, 1905.

IV. The completion of schedules, choice of places for games (in case schools cannot agree) and general arrangements for inter-district contests shall be in the hands of the Athletic Director, Principal C. G. Wade of Flint. His rulings are to be complied with, but protest after a game may be made through him to any one member of the State Committee not in the districts concerned. Eligibility protests in inter-district contests shall be referred to the State Committee in the same way, through the Athletic Director.

V. The present Board of Appeals is abolished. The rules have been

rearranged and simplified with practically no change in meaning. The North Central Association of Colleges and Secondary Schools has lately made 20 years instead of 21 the age limit for high school athletics. It would be helpful if Michigan should adopt that change another year. While there are still some points in this plan of management that will need the test of experience, your committee believes that the main point desired by the schools has been secured, namely, a more thorough representation in the general management. It is sincerely to be hoped that the schools interested in athletics will strive to make that management judicial and impartial.

Respectfully,

S. O. HARTWELL,
L. L. WRIGHT,
D. W. SPRINGER,
A. J. VOLLAND,
WEBSTER COOK,
Committee.

RULES GOVERNING MICHIGAN SECONDARY SCHOOL ATHLETICS.

Personal Eligibility.

1. No person shall be qualified to represent any school under this agreement in any athletic contest with members of another school or other schools unless he shall have been enrolled as a member of the school from the first of October or the first of March in the semester in which the contest or event takes place. Students over twenty-one years of age when enrolled for the semester shall be excluded from participation in inter-school contests, and no student shall play on secondary school teams or contest in secondary school athletics for more than four years.

2. No person who has represented any school in inter-school contests in any capacity during a semester and whose school connection has lapsed shall be again eligible to represent such school in any athletic capacity until he shall have been in regular attendance for a whole semester. Absence for more than two weeks for any reason other than disabling sickness shall be deemed "lapse of school connection" under this rule. (Doubtful cases should be referred to the proper Board of Appeals.)

3. Any person who has ever used or is using his athletic skill, or skill in athletics, for gain, or who has competed on any college athletic team, shall be barred from participation in any inter-school contests. Any student going from one secondary school to another must present a certificate from the superintendent or principal of the school left, showing his eligibility under the athletic rules, before being allowed to compete in any contests.

4. All candidates for membership in foot-ball teams may be required to pass a physical examination and have their parent's consent to play.

School Standing.

5. No student shall be allowed to represent his school in athletics in any capacity whatever unless his marks, from the beginning of the semester to the time of the game to which he is certified, shall average the grade designated by said school as passing, in each of at least three studies comprising not less than twelve hours of credit work per week. (In determining credit, laboratory work may count for one-half.) The average standing to be determined according to the system in operation in each particular school.

6. Any student failing to pass at least ten hours of his school work during any semester shall be ineligible to play or contest in any inter-school contests until his record shall show ten hours for that semester completed according to the rules of the school.

Concerning Schools.

7. A principal's or superintendent's certificate as to the standing of the representatives of a school under this agreement shall be required before every contest. Each candidate for a team shall sign a statement giving the day, month and year of his birth and certifying his eligibility under Rule 3. This statement shall be taken as a legitimate basis for the principal's or superintendent's certificate until evidence to the contrary is found.

8. Any school failing to meet a game scheduled without giving a week's notice shall be barred from competition in inter-school series of games or contests for one year (subject to decision of Board of Appeals).

9. The entire management of high school athletics shall be vested in students or teachers.

Concerning Contests.

10. Either team in a foot-ball contest may demand an official or officials from the Athletic Director, the expense to be divided equally between the two teams.

CONFERENCES

CLASSICAL CONFERENCE

The Eleventh Classical Conference was held at Ann Arbor, Michigan, on Thursday and Friday, March 30 and 31, 1905. All the sessions of the Conference were for the first time held in Sarah Caswell Angell Hall, which will probably be the regular place of meeting in Ann Arbor hereafter. There was a good attendance, representatives being present from many high schools and private schools, several normal schools, and a dozen colleges and universities in the states of Michigan, Ohio, Indiana, Illinois, Iowa, Pennsylvania, New York and New Jersey.

The regular sessions of Thursday morning (commencing at eight o'clock), Thursday afternoon and Friday afternoon were given to the reading and discussion of papers. Thursday afternoon at 4:30 o'clock Professor Andrew F. West, of Princeton University, gave an address on "The Lost Parts of Latin Literature"; on Thursday evening, a joint session of the Classical and Modern Language Conferences was held, to listen to an address by Professor William Gardner Hale, of the University of Chicago, on "Prevailing Methods in the Study of Mood-Syntax in the Indo-European Languages," which was preceded by an interpretation of the remains of ancient Greek music. At the close of the address an informal reception was held in the parlors of the Barbour Gymnasium.

At three o'clock on Friday, Professor Arthur Fairbanks, of the University of Iowa, delivered before the Conference an illustrated lecture on "The Elusinian Mysteries"; and at four o'clock the audience was favored with another lecture, also illustrated, by Professor James C. Egbert, of Columbia University, on "The Ara Pacis of Augustus and its Restorations."

The presiding officers of the various sessions were: Thursday morning, Professor Francis W. Kelsey, of the University of Michigan; Thursday afternoon, Principal Lawrence C. Hull, of Michigan Military Academy; Thursday evening, Professor A. G. Canfield, of the Department of Romance Languages, University of Michigan; and Friday afternoon, Professor R. M. Wenley, of the Department of Philosophy, University of Michigan.

Five of the speakers made use of illustrations with the stereopticon; and two others presented large and carefully prepared drawings. Two of the papers, by Professor R. M. Wenley and Mr. Edwin L. Miller, which had

been prepared for the Classical Conference, were read at the general sessions of the Schoolmasters' Club on Friday and Saturday mornings.

Many of the most important addresses and papers were published in the recent numbers of the *School Review.*

CONFERENCE OF PHYSICS AND CHEMISTRY

REPORT OF THE COMMITTEE ON A "LIST OF EXPERIMENTS" FOR BEGINNING CHEMISTRY

It did not seem best to the committee to mention or refer to text-books and laboratory manuals for obvious reasons, but it has been the aim of the committee to propose a list that could be followed by teachers using the various text-books now found in the schools. The list is not intended as a laboratory manual, but embodies the committees's idea of the order of subjects and experiments, and it seemed best to indicate the experiments as briefly as possible in order to allow the teacher to carry out the details in his own way. It has the defect that it leaves some doubt as to the exact amount of work to be done, but on the other hand it leaves the teacher considerable latitude to use experiments from various sources and especially to develop his own experiments. For example:

Experiment 1. Bunsen Burner.

The student should become familiar with the construction of the burner, the peculiarities of the flame (the phenomena of striking back) and know the hottest part and that there is no combustion in the central zone, etc. There are a number of experiments in the various text-books that cover these points and others can be readily devised. The oxidizing and reducing flames are best studied when the student has had more chemistry.

Experiment 4.

The idea is that the student is to perform a sufficient number of experiments to give him a good idea of the difference between a mixture and a compound. It is hinted that the interesting experiment with "gunpowder," separating by dissolving out the saltpeter with water and sulphur with carbondisulphate, and the familiar one with iron filing, and sulphur, are the kind of experiments wanted. These may be replaced by better ones or more may be added as the teacher thinks best.

Experiment 6.

"Weight of a liter of oxygen" can be done in various ways, fully described in text-books and manuals, so it is not described but left to the teacher's choice. It is suggested that each school should have a small reference library of the most common books and it might be well for the conference to discuss this point. It is hoped that the appended list will be thor-

oughly discussed and may form the starting point of a thorough study of the teaching of chemistry by the teachers of Michigan.

G. A. HULETT,
G. O. HIGLEY,
F. C. IRWIN,
B. W. PEET,
Committee.

LIST OF EXPERIMENTS FOR BEGINNING CHEMISTRY.

1. Bunsen Burner. (Omit oxidation and reduction).
2. Simple work in cutting and bending glass. Construction of a wash bottle. Use of cork borers.
3. Measurement of mass and volume and their relations (specific gravity).
4. Physical and chemical change.
   (a) Mechanical mixture. (Gunpowder, iron and sulphur).
   (b) Chemical compound (Iron and sulphur).

Oxygen.

5. Preparation from mercuric oxide, potassium chlorate, and from the chlorate and manganese dioxide mixed.
   (Method of collecting and handling gases).
6. Properties of oxygen. Test with a splinter. Burn carbon, sulphur, phosphorus. Test reaction of water solution of oxides.
7. Weight of a liter of oxygen.
   Oxidation (Quantitative) (a weight of oxygen that combines with unit weight of magnesium).
   (b) Combining weight of iron determined by oxidation with nitric acid, igniting and weighing as ferric oxide.

Hydrogen.

8. (a) Action of sodium on water.
   (b) Action of iron on water (Instructor).
   (c) Action of metal on acid.
9. Equivalent weight of magnesium and zinc.
   (Gas laws for those who have had no physics).
10. Show that dry hydrogen burning in air produces water.

Water.

11. Purification of water.
   (a) Filtration.
   (b) Distillation.
12. Water as a solvent. Solution and chemical action.
13. Water of crystallization. (Quantitative.) *e. g.*, sodium sulphate or copper sulphate.
14. Composition of water.
   (a) By volume—electrolysis.
   (b) By weight—copper oxide method.

15. Law of Definite Proportions. (Conclusion from Expts. 13 and 14 and some other experiment.)

Chlorine.

16. Electrolyse common salt solution. (Teacher's experiment.)
(Method given in proceedings of chemical conference).
17. (a) Preparation from manganese dioxide and hydrochloric acid.
(b) Preparation from bleaching powder.
18. Properties of chlorine. Combustion of hydrogen, phosphorus, antimony and sodium in chlorine.
19. Chlorine water. Bleaching.

Hydrochloric Acid.

20. Preparation.
(a) See 18.
(b) Sodium chloride and sulphuric acid.
Properties:
(a) Solubility in water. Saturate 5 grams of water in a weighed test tube surrounded with cold water and weigh, also measure the volume of solution and calculate the specific gravity.
(b) Action on litmus.
(c) Action on iron, zinc, magnesium, and copper.
(d) Action on bases.
21. (a) Properties of Acids.
(b) Properties of Bases.
(c) Properties of Salts.
22. (a) Neutralization. Quantitative.
(b) Ionization.

Atmosphere.

23. (a) Analysis by alkaline pyrogallel.
(b) Test for carbon dioxide.
(c) Test for water. (KOH.)
Hint: Plants absorb carbon dioxide and give up oxygen.

Nitrogen.

24. (a) Preparation from air and hot copper. (Instructor.) See also 23a.
(b) Preparation from sodium nitrite and ammonium chloride.

Ammonia.

25. Preparations—by heating ammonia water.
Properties: Solubility in water. Test with hydrochloric acid on a glass rod. Litmus and odor.
26. Prepare an ammonium salt and decompose by heat.
Treat ammonium salt with a fixed alkali.

27. Teacher's experiments.
    (a) Decompose ammonia by chlorine.
    (b) Decompose ammonia by sodium hypobromite (NaBrO).
    Note.—To make sodium hypobromite. 10 grams of sodium hydroxide plus 100 c.c. of water cooled well, 6 c.c. of bromide added, keeping solution cool.

Nitric Acid.

28. Preparation.
    Properties:
    (a) Oxidizing power on ferrous sulphate.
    (b) Oxidizing power on sulphur.
    (c) Solvent power on metals, copper and iron.
29. Analysis of nitric acid. Prove that it contains:
    (a) Hydrogen ions.
    (b) Nitrogen. (By the action of aluminum on sodium hydroxide and adding nitric acid, ammonia is liberated).
    (c) Oxidation of ferrous sulphide or sulphur.
    (Method given in the proceedings of the chemical conference). Test for nitric acid. (Ring. test.)

Oxides of Nitrogen.

30. Nitrous oxide. Preparation from ammonium nitrate.
    Properties.
31. Nitric oxide. Preparation and properties. Solubility in ferrous sulphate. (Explanation of the ring test.)

Halogens.

32. Preparation of (a) Bromine and (b) Iodine. (See Chlorine Expts. 16 and 16). Preparation of hydrofluoric acid and demonstration of its etching power. Displacement of the halogens by each other. (Periodic System).

Sulphur and its Compounds.

33. Sulphur.
    (a) Action of heat upon sulphur.
    (b) Distillation, allotropic modifications.
    (c) Solubility in water, carbon sulphide, etc.
    (d) Formation of ferrous or copper sulphide.
34. Hydrogen Sulphide. Preparation from ferrous sulphide.
    Products of combustion in air. Experiments to illustrate the use of hydrogen sulphide as a reagent in qualitative analysis.
35. Sulphur Dioxide. (a) (See Expt. 2). (b) Preparation from copper and sulphuric acid. Under properties show that it is an anhydride, and that it has bleaching properties. Form a sulphite. Oxidize it to the sulphate.

36. Sulphuric acid. Prepare in a bottle (concentrated nitric acid and sulphur dioxide; add a drop of water).

Properties:

(a) As a dehydrating agent.
(b) As an oxidizing agent.
(c) As a decomposing agent upon salts.

Normal and acid salts.
Tests for sulphuric acid.
Insoluble sulphates.

Phosphorus.

37. Compare yellow and red phosphorus. (Consider the preparation of phosphorus from a phosphate). (Instructor manufacture matches).
Study meta, ortho, and pyrophosphoric acid.

Arsenic.

38. Reduction of arsenic trioxide with carbon. (Instructor show arsenical pyrites, orpiment and regular).

Carbon.

39. Preparation of charcoal from wood.
Decolorizing property of charcoal.
Carbon a reducing agent.
40. Carbon Dioxide. Preparation. Test properties of gas
Show that it supports the combustion of sodium and magnesium.
Solubility in water.
41. Normal and bicarbonates.
(Calcium hydroxide plus carbon dioxide in excess). Discuss the geological significance of this reaction.
42. Quantitative. Per cent of carbon dioxide in calcium carbonate. (One method suggested in proceedings of chemical conference).
43. Distillation of soft coal. (Teacher's experiment).
Collect tar and show test for carbon dioxide, hydrogen sulphide and ammonia. (Method given in the proceedings of the chemical conference).

Typical Study of a Metal.

Copper:

(a) Prepare copper from copper oxide before the blowpipe.
(b) Prepare copper from copper sulphate electrolytically.
(Note.—Make brass).
Physical properties of copper. Color, malleability, etc.
Solubility in dilute and concentrated hydrochloric, nitric, sulphuric and acetic acid.
Action of hydrogen sulphide on solution of copper and separation of copper from zinc in brass.
Preparation of copper sulphate crystals from copper.
Determination of water of crystallization.
Preparation of copper nitrate crystals and decomposition by heat.

WHAT SHOULD BE TAUGHT IN BEGINNING CHEMISTRY.

PROF. F. C. KEDZIE, MICHIGAN AGRICULTURAL COLLEGE.

By plotting the path of scientific educational progress from earliest times to the present we shall find its movement has been centripetal—from the orbit of the farthest planet to the work of the newest discovered microbe.

Astronomy was an exact science long before chemistry had become distinguishable from charlatanry.

Each progressive step is one by which some fact is developed affording us a clearer insight into our surroundings, giving us more exact knowledge of how we stand related to the soil, atmosphere, and plants. If we compare the few who now pursue astronomical study with the members who study matters closer at hand it will show us the mighty change in educational ideals from the past to the present.

Manual training in the high school is here, agriculture even in the common school is coming. We say to ourselves at our clubs and conventions that "we teachers" have accomplished these changes and betterments, but in my opinion it is not the teachers but the pressing demands of the progressive practical citizen who has forced these alterations in our school and college courses.

While the many changes in the curriculum of study hinted at have been made, chemistry itself during the past 50 years has grown from a subject formerly presented only in the lecture hall in the form of a wonderful and interesting set of lectures and demonstrations accompanied by an appropriate number of explosions more or less thrilling in character, to a more quiet study of simple phenomena in the laboratory by the student himself. The lecture hour is now used mainly as a guide to the student for his individual research later in the laboratory.

What the beginner in Chemistry shall first study is not a matter of prime importance provided it be something with which he can easily and safely experiment, and of which he has had previous familiar knowledge. In short something the beginner "knows all about" but can add to what he knows by your help.

A beginning must be made at some point in the student's horizon of experience, and it seems reasonable that the more familiar the object studied the easier it will be for the beginner to get clear conceptions.

Oxygen, the all-pervading, all-important element, seems logically to deserve first consideration. For several years past I have led the beginners' attack on the subject by a study of air and the action of the common metals, copper, iron and zinc when heated upon it.

Difference of point of view may lead many teachers to adopt some other avenue of approach. At the Michigan College of Mines, Dr. Koenig draws his first conclusions from the "lesson of limestone"—comparing physical

and chemical properties by illustrative experiments involving a study of crystalline form and showing action of calcite on light, action of heat on the powdered mineral and then of acids. His second lesson is drawn from hardwood ashes.

The Greek proverb says "Know thyself," and its suggestion may well be followed in the choice of elements to be studied by the beginner. Taking the elements which compose the mass of organized materials we have C, O, H, N, Cl, S, P, of the non-metallic class, K, Na, Ca, Mg, Mn, Fe, of the metals. Besides these elements necessary to the growth of animals and plants we should also include the balance of the halogen and carbon group and the important useful metals.

One of the most essential truths which should be emphasized from the start and which the teacher himself should fully realize is that Chemistry is a practical science and does not exist in any text-book, and that its truths are of far greater practical importance outside of the laboratory than they are inside. Bring out strongly the idea that we live our daily lives surrounded by chemical changes unseen and unnoticed by us which all our laboratory study but partially fit us to comprehend, and which we are likely never to entirely appreciate. Whenever possible introduce an experiment which touches the daily life. Fresh well water filled into a glass flask with vigorous green leaves placed in bright sunlight will yield enough oxygen in the course of a few hours to cause the spark on a splinter to glow and will give the beginner a glimpse of the work in nature's laboratory. There is more carbon in the atmosphere than in or on the earth's crust. Eight tons of carbon exist as CO_2 over each square acre of the earth's surface.

Determination of the amount of water of crystallization is a good laboratory exercise but let the beginner also determine the per cent of water in a hard boiled egg, a piece of bread or a bit of fresh beef. His ideas will be enlarged regarding how much liquid (water) constitute what we commonly speak of as *solid food.*

Make the experiments in lecture room and laboratory simple and direct. Do not use a complicated compound to accomplish what a more simple substance will do. Use hot reduced copper and not alkaline pyrogallol for absorbing O in analysis of air if you have or can rig the proper working apparatus. Derive every conclusion at the start from direct experiment. Do not make a statement and then endeavor to prove the truth of your statement by an experiment—the experiment should come first and the truth be derived from logical steps from the result of the experiment. Progress by this method is slow but sure. The principal advantages gained are:

1. The beginner must understand what are the details of the experiment (training observation).

2. He will reason for himself.

3. He does not learn the truth from a statement made by you, but from an observation made by himself.

The exact order in which the first elements are studied is not of supreme importance, but let there be some logical connection in the order in which

you consider the elements which will appeal to the student's mind. Study the more common substances first. As an example we will suppose that we start with air and find that hot metals will take something from the air which causes the metals to gain in weight and the air to lose its power of letting a candle burn in it. We ask our beginner what other substance next to air is most common—on his replying that water is the substance we then show that water passed over hot metals undergoes a similar change such as the air experienced and that a gas is obtained which does not allow a candle to burn in it, while at the same time the heated metal has gained in weight and appears as though it had been heated in air. The student without difficulty infers that air and water therefore contain a common kind of matter, although he has not yet seen it but simply its effects, and that the gaseous portion not absorbed by the metal from air and that unabsorbed from water while both are colorless and extinguish flame can be easily distinguished by the burning of one gas that, from water, on testing with a taper, and the negative result with the other obtained from air.

You remark, "But all this is no novelty—it is all in print in our text books." True, indeed! This experiment studied by the student from the printed page is of little value—if, however, it is brought before him by actual performance in the lecture room or laboratory it leaves a lasting impression and serves as a sound basis for a beginner's knowledge of the two greatest objects of study—air and water.

The decomposition of water by electrolysis might follow next, then a study of O and H by themselves, including methods for their easy preparation. We then pass to the study of solid common salt and contrast its stability with the unstable compound which yielded O for our experiments, $KClO_3$.

Determining that heat alone will not affect salt—it is dissolved in water and electrolyzed, yielding by double decomposition with the water—Cl—H and NaOH. Next should follow the work with HCl and Cl, (I put HCl before Cl because it is more simply prepared and because the student can appreciate better how salt acting on H_2SO_4 yields HCl gas—after experimenting as he has just done with the action of zinc on H_2SO_4.

I need not detail further how by various natural relationships other elements may be taken up and studied, but progress should always be by stepping stones—not so far removed from each other that the distance will appear to require a jump by the beginner. We *do not* want him to "jump at conclusions" and so aim to have his progress steady and gradual.

Many of the earlier expounders of chemical knowledge filled the first third of their books with matter relating to the general properties of matter, including also chapters on heat, light, electricity, etc., which many of us nowadays require the beginner to have previously studied under the title of "physics." I have found it best to supplement this knowledge by direct physical experiments wherever they have some specially important chemical bearing.

For example, the evolution of heat by chemical combination becomes familiar to the student as he progresses in laboratory work, but that there is a quantitative relation is generally overlooked. A simple experiment which brings the quantitative side prominently forward in the action of HNO_3 on reduced copper saved from the copper oxide reduction experiments.

Using 10 c.c. of HNO_3 in test tube with a thermometer for stirrer I found that dropping into it ½ gram copper gave a rise of 15.4°. Repeating the experiment with a different weight of copper but same quantity of acid I obtained a rise of 31° and ask my beginners how much copper used. 1.006.)

Nothing is more fundamental than Avogadro's hypothesis. For the beginner to comprehend this theory he must know that all gases have the same expansion coefficient.

Professor Hofmann's apparatus illustrates the general fact of equal expansion of all gases for equal increments of temperature admirably, but does not give us any means of arriving at the figure .00366 (the mathematical coefficient) which we use so often in our calculations. Lately I have tried to determine this constant by such crude apparatus as a glass flask of known capacity plunged into a hot water bath, collecting the gas expanded over the same hot water bath in a graduated tube. Here are two results from my note book: Air .0036, H. .0038.

The idea of concrete molecules of gases and molecular motion the beginner best gains by comparison of their velocities by simple experiments in gaseous diffusion—helped out by the failure of an effort to force the molecules through the porous septum by direct compression. Further knowledge regarding molecules is added to by experiments in weighing the gases under like conditions. We found last term O weighed 15.68—Cl 35.29—N 13.92 times H. Having found the weight of a litre of H and Cl gases we next weigh HCl gas and ask ourselves how we explain the fact that one litre of Cl plus one litre of H weighs enough to make two litres of HCl gas—splitting of the molecules—the idea of atoms established.

So far I have taken your time in discussing what is largely brought out in the lecture room period. Far more important and much more difficult to carry forward with large classes is the laboratory work. The first two or three laboratory experiments should be performed under the direct personal direction of the teacher but without the use of any guide in the nature of a manual or printed sheets. The beginner will then pay better atttention to what he himself is doing and less to what the directions say he should do. He will also be more observant of what is taught him at the lecture or recitation period.

From the first I have felt that carelessness on the part of the student was induced by a course in "phenomena experiments." By this expression I mean that kind of experimentation on the part of the student in which he is to do something and simply note what occurs. You may require him to weigh and measure the various materials which he uses for his experi-

ment, but if at the end of the experiment he does not have a final weighing and calculation he is not much more benefited than if he had been permitted simply to "dose out" his materials.

The past year we have had each beginner devote as much time to experiments of a quantitative character as of the purely phenomenal. Simple open-pan balances costing $8.75 and permitting weighing to a milligram have enabled our students to keep improving in exactness from day to day and see for themselves that they could become more expert.

Introduce plenty of simple mathematical calculations wherever possible, but always have them based on a weight experiment performed by yourself or the student. Do not murder the student's interest by giving him such problems as this to work: "What per cent of crystallized blue vitriol may be obtained from water cement of which 150 pounds have the capacity of making an iron bar placed in it weigh 250 grams heavier?" (Stammer's Chemical Problems, ex. 21, p. 54). How old was Ann? would be of more interest and fully as important.

Give variety to the work by performing yourself occasionally some experiment at the close of the period, announcing that the conclusions to be drawn from the experiment are to be discussed by the class at the next recitation. Never perform yourself nor have the student perform an experiment which has no scientific nor practical value, but is simply pretty. Lay emphasis on tests for elements and compounds from the beginning. A test for an element is simply one of its distinguishing characteristics and it can be well considered at the time the first study of the element is begun. Nothing is gained by postponing "tests" until qualitative analysis is reached. Always exhibit, if possible, the natural source of the element. A small collection of the more important minerals is of the greatest value for this purpose.

Chemistry cannot be "carried by assault"—like Port Arthur, it must be approached gradually and tunnelled into before even the outworks can be surmounted.

At one time with my classes I spent a good deal of time at the very first "studying the plans of the fortifications" by the use of text books. How we did study and recite definitions of the terms: Atom, molecule, atomic weight, and molecular weight. Using the word "Crith" frequently to help us out. These terms and definitions came first in the text book and so I thought must be first attacked and conquered. Had we any facts of our own derived from experiment from which to draw conclusions illustrating a need for these definitions? No, certainly not—but bye and bye we should need to use these terms, we were assured by the text book writer, and so loaded them in. I am not here today to oppose the use of a good text book by the beginner in chemistry, far from it. We beginners need all the help we can get, but at best a text book is only an aid. The object of chemical study should be "the thing" itself to know its properties at first hand, and the beginner becoming accustomed to experiment and reason for himself

is enabled to work out his own chemical salvation, *assisted* by the text book and teacher, but *dominated* by neither.

The best text book for the beginner is not one which tells him all about it, entering into the minutest detail, but rather the one which stimulates him to reason for himself and extend his knowledge beyond book-described experiments.

We cannot know it all. In Ostwald's Conversations on Chemistry (a dialogue which I recommend as being full of good things for instructors to ponder) the master says:

"M. Today we will learn more about oxygen.

"P. I know about it already.

"M. Only very superficially, for you only know a very small part of what is known about it, and what I am going to tell you is only a little part of what is known.

"P. But you know all about it.

"M. No, I do not think there is a single man who really knows all that is known about oxygen."

I have digressed too largely, perhaps, from my assigned topic, but I feel strongly that the good accomplished by chemical study is as much, if not more, due to the mental development and training afforded the beginner as to the greater familiarity with elementary substances and compounds with which he is brought into contact in the course of his study. Few of us who study chemistry ever make it a life specialty. The value of the work to the average student then must lie in the training which it gives and, if properly presented, the better view which he gains of his relation as a living individual to the universe of matter.

THE CHEMISTRY NOTE BOOK.

E. J. WILSON, ADRIAN.

The senses are the servants of the mind, they are the channels through which it obtains knowledge; if we were to cut them off, the mind, if it could exist at all, must do so in perpetual darkness. We understand and remember best, what we see and do. All knowledge is gained by sense impressions. In the laboratory knowledge is gained by means of all the senses; we see, hear, feel, taste, and smell,; handle, weigh, measure and compare. If properly conducted laboratory work is, therefore, excellent training, not alone in sense perception, but in logical thinking or reasoning as well.

If it be true, that knowledge is gained by means of the senses, how important it is that the senses be trained, so that they may furnish us with right impressions and thus lead us to form correct perceptions or ideas. A good course in laboratory work is the best sense training; it harmonizes the action of eye, hand and brain so that they work in unison.

Every idea tends to, and should find expression, either in a word or an act. Our pupils receive sense impressions and thus gain ideas in the laboratory. They also have an opportunity to give expression to some of these ideas in the manipulations required and of more of them directly to us in the laboratory, during the progress of the experiment, or later in the class room quiz. We cannot give every pupil an opportunity to express himself orally; and even if we could, the first crude expression needs clarifying, clothing in better English, and stating in a clear, simple way that means exactly what he wishes to express,—no more and no less,—thus the function of the laboratory note-book. The pupil here finds an opportunity to express the ideas obtained in the laboratory,—and not that alone,—but to compare certain facts, and by a process of reasoning, draw definite conclusions from related phenomena. It seems to me that this process of reasoning is of inestimable value. Man differs from the lower animals in that he has the power to think, to reason, and compare. Every exercise of mind which requires reasoning is, thus, an aid in lifting man above the brute; in raising him toward his proper sphere as a being that finds the greatest pleasure in the things which pertain to the mental life.

If the note-book is to serve this important office, that of a medium by which the pupil is to express and clarify his ideas,—and I believe the idea is not acceptably complete until it is expressed—how important that the data used, the facts stated, and the conclusions drawn shall be the pupil's very own. The order of the development of an idea is first, stimulus, second, sensation, third, comparison or association, fourth, idea. The senses are the avenues to the mind. The more vivid and varied the sense impressions, the more forcible the sensation; the clearer the ideas, and the longer they remain in consciousness. If, therefore, the pupil has not obtained his knowledge at first hand and thus received forcible and varied sense impressions, the ideas, if formed at all, are vague and soon drop into subconsciousness or are entirely forgotten. But are ideas formed? Do not pupils get words without ideas in many instances? The question is how can the note-book be made to best fill its important place in chemistry teaching? When and how and where shall it be written? When examined and how corrected by the instructor? What we want is not an ideal way which is not practicable, but the practicable way which most nearly approaches the ideal. In my judgment, the ideal way would be to require the student to write up all his notes, make his comparisons and draw his conclusions, independently in the laboratory, under the surveillance of the instructor; and not be allowed to carry his notes away with him to be completed; but be required to submit them for examination and correction before leaving the room. As soon as an experiment was completed and satisfactorily written up, the notes could be examined and returned to the student for future reference in reviews, laboratory work, etc.

While I believe the above to be the ideal way I do not consider it a practiceable way, in most high schools. The time given to laboratory work

is too short and can be better spent in becoming acquainted with nature at first hand, than in the analysis and correlation of results, making computations, and attention to the form of record. I do not mean that the pupil should keep no record of the results of an experiment at the time of making the observations; on the contrary, I believe that all results should be recorded at once,—but in a brief way, just enough being written to enable the pupil to recall later the phenomena witnessed in the laboratory. The pupil should, then, in the quiet of his study, make his final record of the experiment. This final record should be written with care and should show thought and discrimination; it should be the pupil's best effort in every way.

As to what should be put in the note-book, it seems to me that either of two plans may be followed. First, the student might be required to tell how he performed the experiment and state the results and conclusions in a connected way so that an examination of the note-book would reveal all the details. Second, he might be allowed to refer to the laboratory manual for manipulations and state results and conclusions only. The latter method takes much less of the pupil's time and shows equally well how the experiment was performed. The references to the manual can be easily made, if the directions are divided into lettered or numbered paragraphs. In case a paragraph contains simply directions for setting up the experiment, the number of the paragraph and the statement—I did as required—is sufficient. If a result is obtained, I believe it should be so stated as to include the conditions which produced it. The former method is the more complete; the more scientific; it is the research method and is to be preferred if time permits. Is it always to be preferred? I do not know.

It seems to me a waste of the pupil's time, to require him to copy lists of apparatus and materials from his laboratory outline. An appropriate diagram should be made; this, with a few words of explanation, will suffice, in many instances, to show how the experiment was performed, and is of value to the student. Many experiments require no diagrams,—those in which nothing but test tubes are used, for example. The lecture experiments, performed by the instructor, should be written up, accompanied by diagrams of the apparatus used, and bound together in a separate portion of the note-book.

I will now present, briefly, the method I am following and leave the subject with you for discussion, hoping that I may receive some helpful ideas from those of riper experience.

At the time of performing the experiment I require each pupil to fill out a data sheet. These are left with me at the close of the laboratory period and are made as brief as possible; just enough being written so that I am able to tell whether they performed the experiment correctly and saw what I wished them to see. I examine this rough record; designate portions to be repeated or indicates its acceptance by a suitable check; give the student credit in my laboratory record book, and return it the following day.

If any portion of the experiment is to be repeated, the student does so, makes the correction in his data sheet and returns it for criticism. When accepted, the experiment is written up on the detached leaves of a permanent notebook. These leaves, containing a record of the work completed during the preceding week, are handed in each Monday and are returned to the student within a few days. A record of relative merit, to be taken into consideration in making out monthly grades and final standings, can, conveniently, be made at the time of examining the notes.

Finally, allow me to state two reasons why I use this method. First, it saves the pupil's time in the laboratory; he is not trying to write elaborate notes while he should be observing or attending to the details of manipulation. Second, it enables the teacher to be reasonably certain that the pupil actually performed the experiment. Of course, we teachers of chemistry, who love the science, may find it difficult to understand why any person should try to avoid performing an experiment; still, we know that all minds are not constituted alike, and that it is somewhat difficult for some people to realize the importance of obtaining a knowledge of nature's laws by direct contact; it, therefore, behooves us to exercise care that one great object of the course in laboratory chemistry,—the acquisition of the scientific method,—be not thwarted.

QUANTITATIVE DETERMINATION OF THE STRENGTH OF AN ACID BY A WEIGHT AMOUNT OF SODIUM

M. A. COBB, LANSING, MICH.

It is difficult for the student to get a practical idea of the strength of an acid. I have found the following method helpful. I first saw the method used at the Michigan Agricultural College; it is also given in Clarke & Dennis' Laboratory Manual.

As illustrative of the method I shall try to determine the acid strength of vinegar. Fill a burette with acid, weigh a watch glass, cut and remove the coating from a piece of sodium the size of a small bean (.100 g to .175 g), weigh as soon as possible; put about 25 c.c. of distilled water in a test tube or tall beaker. Prof. Kedzie uses a beaker with a tube, the lower end in water.

Now drop the sodium on the water; after the action has ceased wash any adhering particles into the dish; add more water (100 c.c.) in using vinegar; titrate using phenol phthalein for the indicator in the case of vinegar.

The sodium will produce a definite amount of sodium hydroxid, which neutralizes a definite amount of acetic acid. From the known amount of sodium we are to calculate the amount of hydroxide produced and the amount

of acid this will neutralize. Dividing by the amount of acid used gives the amount in each cc. Tabulate as follows:

(1) Weight of sodium.

(2) Amount of sodium hydroxide produced: $Na + H_2O = NaHO + H$

23.05 gives 40.05

(1) " how much?

(3) Amount of acid neutralized: $NaHO + HC_2H_3O_2 = NaC_2H_3O_2 + H_2O$

40.05 neutralizes 60

(2) *g* neutralizes how much?

(4) Number of c.c. acid used.

(5) Amount of acid in each c.c. (3) ÷ (4).

(6) If the specific gravity of the acid varies much from 1 this may be found and the % acid calculated, (5) ÷ sp. gr. = — %.

The above experiment can be easily worked in any laboratory. Strong acid may be diluted until it takes at least 5 c.c of the acid for good results, The balance need not be necessarily very sensitive.

The method gives an easy and accurate way for determining the acid strength. This is a source of gratification to the student. It teaches the practical use of formulæ and strengthens his faith in them and gives the student some exact idea of acid strength.

As to the accuracy of the method I give results of several consecutive trials using H_2SO_4.

.04819
.04827
.04800

Another method gave for the same acid .04785.

ANALYSIS OF NITRIC ACID

B. W. PEET, MICHIGAN STATE NORMAL COLLEGE

Chemistry has to deal with the composition of things. Hence, any experiment that illustrates in a simple way the composition of the common chemical compounds is a valuable one for beginning students in chemistry.

Most texts take up the study of acids, bases and salts, and the composition of ammonia before the study of nitric acid, so the student is able to grasp the full meaning of the experiment as here given.

(a) Any solution that contains hydrogen ions will turn blue litmus red. Add a drop of nitric acid to a strip of blue litmus paper. It turns red—hence nitric acid contains hydrogen.

(b) Into a test-tube put 4 or 5 c.c. of water, add 10 or 12 drops of concentrated nitric acid and stand in the test-tube rack or an empty wide-

mouthed bottle. Add a piece of sodium hydroxide about twice as large as a good-sized pea and shake a few times; then add a few pieces of aluminium wire and if necessary heat over the Bunsen flame uitil the action of is quite vigorous. Test the odor of the escaping gas and note its action on moist red litmus paper. It is very evident that ammonia is liberated. When sodium hydroxide is placed on aluminium, hydrogen is liberated and the nascent hydrogen reduces the nitric acid, forming ammonia and water. The student already knows the composition of ammonia and can readily reason that the source of the nitrogen must be from the nitric acid.

(c) Place about a gram of coarsely powdered ferrous sulphide in a test-tube, cover with concentrated nitric acid, and heat a few minutes in a hood. Allow the solution to cool; dilute with two or three times its volume of distilled water; decant a portion of the dilute solution and test for the SO_4 ion by adding barium chloride. A heavy white precipitate of barium sulphate indicates the presence of the SO_4 ion. The student can readily reason out the source of the oxygen. The experiment thus shows nitric acid to be composed of hydrogen, nitrogen and oxygen.

QUANTITATIVE RELATIONS BETWEEN ACIDS, BASES AND SALTS—THE PREPARATION OF PRIMARY AND SECONDARY SALTS OF SULPHURIC ACID

R. R. PUTNAM, EASTERN HIGH SCHOOL, DETROIT

There seems to be little call for a lengthy report upon this subject just now. The main part of the matter was so thoroughly covered by Mr. Irwin last year that there is little to be said. In his report he described experimental work that has been successfully presented for several years. This work covers the ground well, and I do not at present see that it can be much improved upon.

The works is as follows:—Normal solutions of caustic soda and caustic potash and of sulphuric, hydrochloric and nitric acids are provided. From these each pupil prepares about half a liter of decinormal strength. The basic solutions are then titrated against the acids, using phenolphthalein as indicator. For this purpose two burettes may be used, though, probably, it is as well to use one burette and a pipette, as the results are just as satisfactory, and the pupil gets some practice in the use of the latter instrument. The following calculations should be made from the experiments: (*a*) The number of gram-equivalents of each base required to neutralize a gram-equivalent of each acid. (*b*) The number of gram-equivalents of each acid required to neutralize each base. (*c*) The number of gram-equivalents of the bases of equal neutralizing power. Finally equations for each reaction

may be written, and the numbers given by the above calculations compared with those expressed by the equations. It might be a good plan to introduce one or two "unknowns" at this point. For this purpose solutions of any of the above bases or acids of about semi-normal strength may be given out. The percentage of the base or of acid may be determined by titration and calculation. The pupil can, in this way, easily get hold of the principles of simple volumetric analysis, and the methods of calculating the results of such analyses. It will probably be best to weigh a measured volume of the liquid, and then titrate an aliquot part of this in the ordinary way.

The two sulphates of sodium, for example, may be prepared from the same normal solutions as are used in the above work. Measure out 25 c.c. of normal sodium hydroxide into each of two beakers. Neutralize the contents of one beaker exactly with normal sulphuric acid, using litmus paper as indicator. The contents of the second beaker are likewise exactly neutralized with normal sulphuric acid, the volume of the latter being noted. Then an equal volume of normal sulphuric acid is added. The contents of both beakers are evaporated to crystallization, and the products compared as to solubility, taste, reaction to litmus, melting point and action upon magnesium. The same experiment may be repeated, in all its detail, using normal hydrochloric acid in place of normal sulphuric. The results in the first case are, of course, primary and secondary sulphates of sodium, in the second, common salt. These experiments should serve to open up the question of acid and normal salts, and should show, in some small degree, how the question can be settled. They also have a bearing upon the formula of hydrochloric acid. The results of the experiments, naturally, cannot be taken as *proofs* of anything excepting the fact that we do have two sulphates of sodium, one of which contains hydrogen, and the fact that, *by this method,* we cannot produce two chlorides of sodium. This result in the pupil's mind is much better than that arising from the course of reasoning carried out in too many class rooms and text-books:—"The molecule of sulphuric acid contains *two* replaceable atoms of hydrogen, therefore, we have two sulphates of sodium; the molecule of hydrochloric acid, on the other hand, contains but one replaceable hydrogen atom, hence we can have but one chloride of sodium."

And now, having, rather vaguely, I fear, answered certain questions, I may be pardoned if I ask one or two on my own account. How much, and what theory shall we put into our work? How much atomic hypothesis? What shall we do about valence? How much equation writing shall we attempt? How far is it wise to carry our drill on formula writing? Is it a good plan to make such general statements as, for example, "All common metallic hydroxides excepting those of the alkalie and alkaline earth metals are insoluble in water, the latter slightly so," and then make such general statements the basis of specific statements as to the method of preparing particular compounds? What is the place of the electrolytic dissociation

theory in secondary instruction in chemistry? I hope that this section of the Schoolmasters' Club can take up such questions as these in the near future, and approve some plan of teaching.

THE VOLUMETRIC COMPOSITION OF WATER VAPOR.*

PROFESSOR GEORGE A. HULETT, UNIVERSITY OF MICHIGAN.

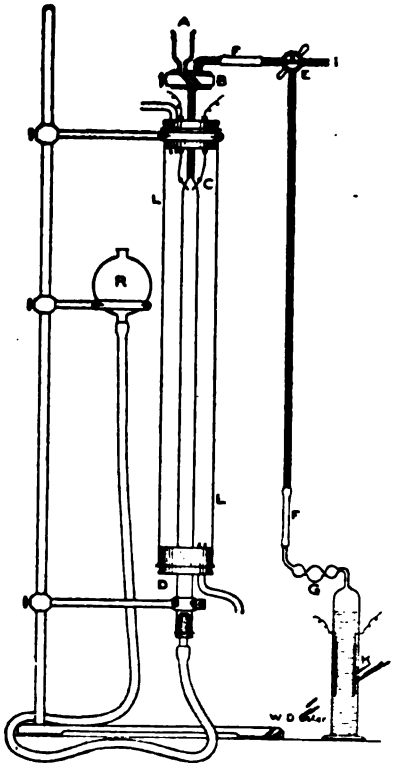
The volumetric relations of interacting gases and vapors are of fundamental importance in our atomic and molecular theories, and Hoffmann has done a very considerable service in devising many experiments to demonstrate these fundamental facts. But the experiment as commonly performed to show the volumetric composition of water vapor is difficult to carry out and most frequently fails as water vapor is very liable to appear in the eudiometer tube when steam is passed through the jacket, and then it is necessary to dismantle the apparatus before another trial. This and other difficulties frequently necessitate postponing the experiment and discussion until the next lecture.

I have used, for several years, an apparatus that gives very satisfactory results, and have been asked to describe the experiment. The apparatus allows one to repeat the experiment without dismantling or even stopping the steam in the heating jacket, and has the advantage of an adjustable mercury reservoir, which is joined by a rubber tube to the straight eudeometer tube. The essential feature of the method is a capillary tube sealed to the top of the eudeometer tube and extending outside the steam jacket. Water vapor can be removed through this tube, so it is not necessary to dry the mercury or tube before setting up the apparatus. The detonating gas mixture (2 vol. H_2 and 1 vol. O_2) is also introduced through this capillary and then the capillary is filled with mercury, closing it at the point where it is sealed onto the eudeometer tube and inside the steam jacket.

The accompanying figure gives a drawing of the essential parts of the apparatus. (L L)) is a glass jacket some 5x60 cm. closed with split corks, which bear the graduated endeometer tube (C D) 1½x65 cm. This tube is provided at (C) with the usual platinum wires and well insulated leads which are joined to a Rhumkorff coil for exploding the gas mixture. At C is sealed in a capillary (1 mm. bore) tube, 12 cm. long and ending in the two-way cock, B. This cock B communicates with the little mercury reservoir A or through the tube (F) to the exit (I) or down to the detonating gas generator K, depending on the position of the three-way cock (E). K, the detonating gas generator, is some 2½x15 cm., provided with small platinum

*A lecture experiment.

electrodes; the generator is provided at G with sulphuric acid drying bulbs; at (F F) are rubber joints to make the apparatus flexible. (With a little skill in glass blowing we can make a very cheap generator from a glass tubing, leaving the bottom of the generator open for a cork which carries two nickel electrodes). It is best to use a 15% solution of caustic soda or caustic potash in the generator, to avoid the formation of ozone. An ampere current will yield about 12 c.c. of detonating gas per minute and about 4 volts is necessary



for this purpose with the above generator. A convenient switch is needed in the battery circuit to make and break the generating current at will. The generator must be allowed to run long enough to remove all air from the generator, dryer, etc., through the cock (E) and exit (I). R is an adjustable mercury reservoir held in a three-quarter ring which allows of its being removed for rapid lowering and raising. The jacket is heated by steam from a large flask of boiling water. The exit is below and if other vapors than steam are used for higher temperature a condenser is attached to the lower outlet.

After the apparatus is set up and steam begins to pass through the jacket, water vapor may appear in the endeometer tube. To remove this

the cocks B and E are turned so as to communicate with the exit (I), and by raising and lowering the reservoir several times the vapor is swept out by the air that is drawn in and forced out. The generator is now started and the cock E turned to bring the gases into the apparatus. After some of the gases have been introduced into the endeometer tube it is well to turn the cock E and force them out through I and then fill for the experiment. When the desired volume of detonating gas is introduced, the battery circuit is broken and the cock B is turned to communicate with the little reservoir A filling the capillary with mercury and closing the endeometer tube off at C. The cock B is then closed. The volume of detonating gas is measured and after lowering the reservoir to rarify the gases they are exploded, and the resulting volume of vapor measured. The experiment can be repeated in a very short time, first removing the vapor as above described. The lead wires must be well insulated and insure a spark at the platinum points. It is well to have one at least pass through a small glass tube in the upper cork. If steam is used in the jacket it will be necessary to measure the vapor formed under diminishing pressure, for the water vapor deviates considerably from the gas laws at the boiling point of water; one can easily measure all volumes under diminished pressure by keeping the reservoir a definite, measured, distance below the mercury in the endeometer tube by using a short measuring stick. If it is considered more desirable to measure the gases and vapor at atmospheric pressure, one may use amyl alcohol, giving a temperature of about 130°, and then a condenser is to be used for the outlet. With a little skill in glass blowing we can easily construct the above apparatus as the cocks used are commonly at hand. Such an apparatus was exhibited at the last meeting of the Michigan Schoolmasters' Club, and gave as a result 20.8 c.c. detonating gas and 14.05 water vapor, and many of the results are even better than this.

A SIMPLE EXPERIMENT TO DETERMINE THE VOLUMETRIC COMPOSITION OF AMMONIA.

LINUS S. PARMELEE, FLINT.

By the use of very simple apparatus it is possible to determine the volumes of hydrogen and nitrogen in ammonia.

This is an experiment that the student can perform successfully and comprehend thoroughly.

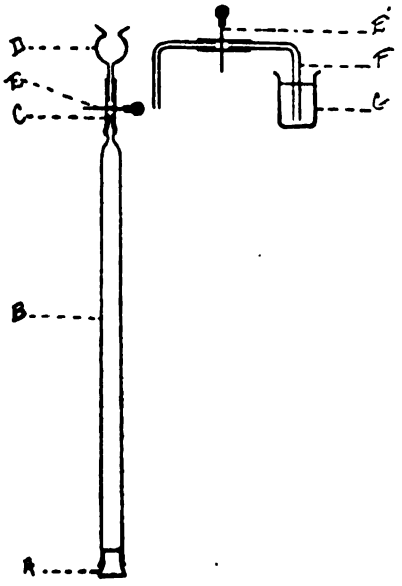
Almost any kind of a tube can be used; plain tubing, gas tube, burette or Hoffmann tube. A tube fitted with a glass stop-cock is preferable.

The tube (B) used for this experiment is a plain burette fitted with a rubber stopper (A) at the large end (P) and a short piece of rubber tubing (C) with pinch clamp (E) at the other end.

From a small chlorine generator that has been running at least ten minutes fill the tube by displacement of water. When full pinch the clamp an instant and let the increased pressure of the gas drive the few drops of water up through the rubber tube.

Allow the tube to stand in the trough till the water runs down the sides, finally adding chlorine, if necessary, to fill it.

Close the open end with the stopper (A) pushed firmly in, and again slightly pinch the clamp. (Do not warm the gas by handling the tube).



Clamp the tube vertically in a support and insert a short stemmed thistle tube (D) in the rubber tube at the top. Pour 10 cm^3 of strong ammonium hydroxide in the thistle tube and work a glass rod up and down in the stem to remove air bubbles.

Measure the length of the chlorine column, making a previously determined allowance for the small end.

Let the ammonia drop slowly into the chlorine till nearly all is used. Remove the thistle tube and tilt the burette so that the ammonia surely uses up the chlorine.

Connect the burette with a beaker (G) of dilute sulphuric acid (1 to 4) by means of a tube filled with water (F). [A convenient form is shown in the diagram. Remove E^1]. Remove the clamp (E) and allow the pressure to equalize. Let the apparatus stand till the remaining gas is of room temperature.

Measure the length of the new gas column.

Test the gas for, odor, color, combustion. What is it?

What have you previously learned concerning the volumes of hydrogen and chlorine that unite?

The hydrogen of the ammonia (NH_3) united with the chlorine. What volume then of hydrogen was used? What became of the nitrogen originally with this hydrogen?

What is the volumetric composition of ammonia?

The actual volumes of chlorine and nitrogen can be determined by measuring the water the tube holds and the volume of the resulting liquid, and subtracting. However, if the tube has a uniform bore the comparison of the lengths of the columns is much simpler and more satisfactory.

A SIMPLE RESONATOR.

M. A. COBB, LANSING, MICH.

A short time ago I noticed the similarity between a Helmholtz resonator and an incandescent light bulb. Acting upon this observation I broke the tip of a bulb and enlarged the opening by means of a file and punched in the cavity carrying the wires.

Holding the small orifice to the ear and the other towards the source of sound as the key board of a piano the air resounds—that is, the sound is louder when its natural period of vibration is struck. "Phonograph tubes may be used to transmit sound to the ear.

The bulb is similar to a Helmholtz resonator and its action is familiar to you.

The ordinary size, 16 c p bulb, with a small opening, responds to about 256 vibrations. As the bulb becomes larger the pitch lowers and vice versa. Here is a 294 c c bulb, the note is c; a 167 c c, the note is e.

As the area of the orifice becomes larger the note is higher; the note of a bulb can be changed by enlarging the orifice.

There appears to be no simple relation between volume or area to the pitch. Londhauss gives the formulæ for circular and flask with a neck as:

$$N = 52400 \sqrt[4]{\frac{\text{area}}{\text{Vol.}^2}}$$

$$N = 46705 \sqrt{\frac{\text{area}}{8\ \text{Vol.}}}$$

I found the constant to be much lower, but with the means at my command could not get check or reliable results.

The bulbs can be used for resonators for analysis of sound and deter-

mining the characteristics of quality. For instance, I found a bulb to resound strong for middle "c," weak for c, and faint for g, proving that the latter strings of the piano were vibrating in two or three parts respectively.

Interference of waves at the edges of a tuning fork can be clearly demonstrated by holding the bulb in various positions and using the phonograph tubes.

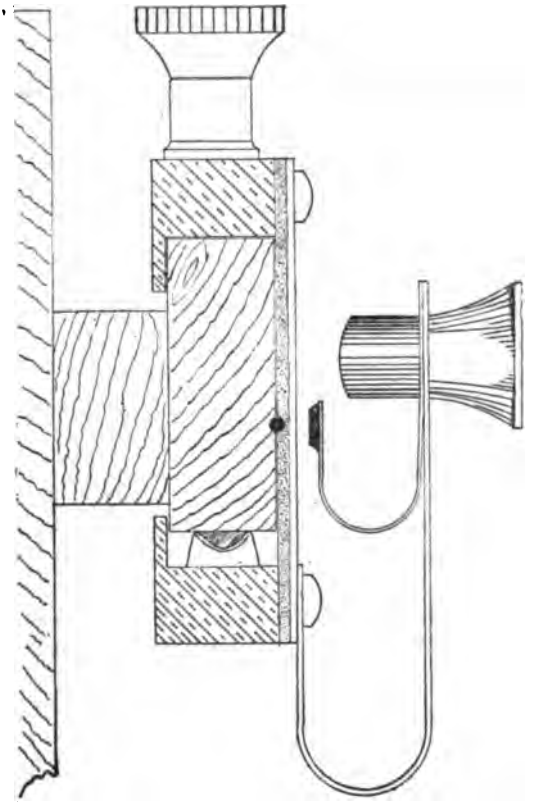
I have fair results in determining the vibration rate of a note by means of the siren, noting when the siren and a resonator were in unison.

The resonators show clearly that confined air has a vibration rate of its own and vibrate freely when the vibrating body is of the same rate.

A CONTACT KEY FOR A SLIDE WIRE BRIDGE.

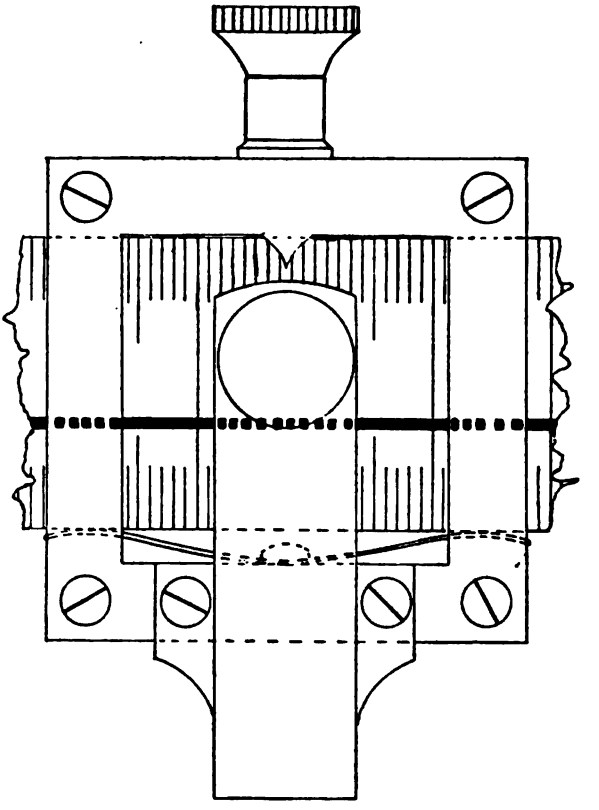
H. L. CURTIS, MICHIGAN AGRICULTURAL COLLEGE.

In designing a contact key for a slide wire bridge the following things need to be considered. It should be possible to operate the key easily. The electrical contact within the key should be good. Either the zero point or the point of contact should be adjustable, so that the two may be brought into coincidence, yet when once adjusted there should be no danger of either



of them changing. It should not be possible to apply undue pressure on the point of contact. A key which answers all of these requirements except the last, is described in Price's "Measurement of Electrical Resistance."

The key about to be described is very similar to this, but has an added feature to overcome this defect. The key is illustrated in the drawing. It slides on a meter stick which is raised a short distance from the base of the bridge. A piece of insulating material (wood fiber is cheap and satisfactory), prevents the wire from touching the metal above. Also because of the wire sliding in grooves, it will always be underneath the platinum point, so that contact is certain when the key is pressed.



Fastened to the frame is a tapping key. Underneath the vulcanite top of this is a stop, which strikes the meter stick when the key is pressed. To this is soldered a thin piece of spring brass, which carries the platinum contact.

The contact point may be made to coincide with the pointer by moving the tapping key in slots (not shown in the drawing) where this is fastened to the frame.

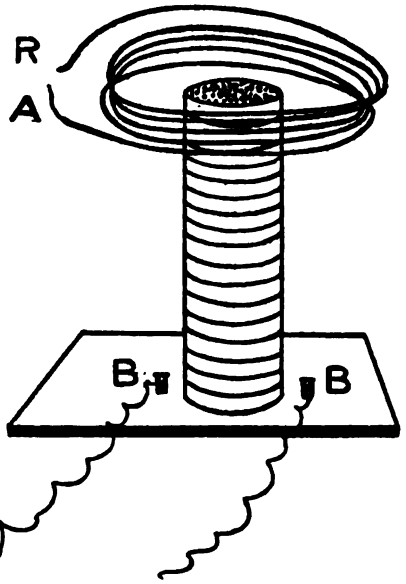
This key has been used for two terms, and has given very satisfactory results.

A SIMPLE STEP-UP AND STEP-DOWN APPARATUS.

DE FORREST ROSS, YPSILANTI.

The above heading, though not a misnomer, covers only a part of the possibilities of this simple and inexpensive apparatus. As many of the high schools are now equipped with the alternating current for lighting purposes, it occurred to me that this current might be used for demonstration work in the physical laboratory. The electro magnet before you is the outgrowth of that idea, suggested by some experiments of Professor Carhart at one of our physical conferences.

First, then, is to make the magnet, as, so far, I have been unable to find anything in the market that will answer the purpose. Procure of your



hardware dealer twenty to twenty-five pounds of No. 16 annealed iron wire, and cut it into pieces about fifteen inches long. Bind these in a compact bundle with electric wire tape, and make the top level by driving the wires down with a hammer. This will constitute the core of the magnet. Fasten the core to the base in an unright position by cutting a hole in a board just large enough to admit the end of the core. Bend enough of the wires over around the outer edge to hold the core firmly in position and fasten them to the under side of the board with staples. Then by driving wedges between the wires, the core can be made to stand rigidly in its place. Nail another board on the under side to cover up the uneven ends of the core and it is ready for winding.

Begin at the bottom and wind in smooth, close coils four layers of No. 12, double covered copper wire, to within one inch of the top and fasten the ends to binding posts in base. The whole coil should now be covered with electric tape.

Several coils of well insulated copper wire should be made, varying in size of wire, diameter of coils, and number of turns in each. These should be fastened with tape for convenience in handling, leaving the ends long enough for connections.

With a coil of fifty or sixty turns of No. 12 copper wire wound so as to fit rather loosely the primary coil, the terminals connected by a No. 16 copper wire, and the coil lowered to the centre of the magnet, an induced current will be produced strong enough to quickly fuse the wire and cause the copper to boil like water. Iron wire between the terminals will burn with brilliant scintillations. The operation, however, can hold the naked terminals in his hand without feeling the slightest effects of the current. This illustrates in a forcible way a step-down device.

If a coil of five hundred or six hundred turns of No. 20 wire be used, the potential becomes so high that it will make an electric lamp glow intensely, and by attaching handles to the terminals and slowly lowering the coil from some distance above the magnet, a range of physiological effects will be experienced, varying from an almost imperceptible pulsation to that of sufficient strength to satisfy the most ardent. These are only suggestions of things one can work out, once started along this interesting line. You will also be surprised to see the interest your students will take and how much they will get from this, to them, most difficult part of electricity.

CONSERVATION OF ENERGY WITHIN THE HUMAN BODY.

ARTHUR W. SMITH, PH.D., UNIVERSITY OF MICHIGAN.

The nutrition of the human body is a subject of great importance to every one of us. Whether we realize it or not, it is presented to us three times a day, and more or less wisely we attempt to reach a satisfactory solution of the problem. The question has also been attacked from the scientific standpoint by a number of investigators, and in the brief time at my disposal I want to give you the results of some experiments along this line.

In so far as the material phenomena are concerned, life consists of transformations of matter and energy. It is commonly assumed that these transformations follow the laws of the conservation of matter and the conservation of energy, although the experimental proof that they do has been lacking. In order to show that the law of the conservation of energy holds true in the body one must be able to measure the energy received

from the food, the energy expended as muscular exertion, that given off in the form of heat, and the loss or gain in the store of energy in the body. This last is the most difficult factor to determine. If the body is warmer at the end of an experiment than at the beginning, or if it has a larger store of fat, it has gained energy. On the other hand, if its store of fat has decreased or its temperature is less, it has lost energy. If then it can be shown that the total energy received by the body just equals the total energy expended, plus or minus the gain or loss in the store of energy, it would be a direct confirmation that the law of the conservation of energy holds in the living organism.

A number of investigators have experimented along this line. Most of them have studied the balance of carbon, or nitrogen, or both. About 1892 Professors Atwater and Rosa began an investigation which has demonstrated that not only did the law of the conservation of matter hold true, but also that the income and outgo of energy balanced as well. The investigation, which is still in progress, is a most difficult and intricate one, requiring untold labor and infinite care for details. The work has received generous aid from Wesleyan University, Storrs Experiment Station, Congress and the Carnegie Institution. A number of skilled investigators have been busy for a dozen years and are still at work. Much valuable information regarding the nutrition of man has been obtained, and a full account of the work would fill many volumes. The most interesting phase of the investigation, however, is the light it throws on the purely scientific question of the conservation of energy.

The apparatus consists of a chamber, 4 ft. by 7 ft. by 6 ft. high, in which the subject of the experiment lives, eats, drinks, sleeps and works, during a period of several days and nights. An abundant supply of fresh air is constantly supplied, and there are arrangements for keeping the chamber at a constant temperature. The heat given off from the body of the man in the chamber is carried away by a current of cold water, which passes through a series of pipes inside the chamber. By properly regulating the temperature of this water and also its rate of flow, it is possible to maintain a constant temperature within the chamber. When this is the case the heat is being carried away just as fast as it is generated. The heat thus removed is easily determined, knowing the amount of water and its increase in temperature.

In order that the heat, thus carried away from the chamber, shall exactly represent the amount given off by the man within, it is of course necessary that no heat shall enter or leave the chamber through its walls or by the ventilating current of air, and due care has been observed that such is the case. Since a man eats and drinks a large amount of liquid water and gives it off in the form of vapor, quite a large amount of heat is required to vaporize it, and this heat must be added to that measured directly by the calorimeter.

Before commencing actual experiments with men it was necessary to

test the accuracy of the apparatus as a calorimeter. For this purpose two kinds of tests were employed. In the first a known amount of heat was produced within the chamber by passing an electric current through a coil of wire, this heat being absorbed by the current of cold water, carried away and measured as described above. The second form of the tests corresponds much more closely to the actual case of a man. An alcohol lamp within the chamber burns a weighed amount of alcohol. This produces heat, water vapor and carbon dioxid, which quantities are in turn measured by the apparatus. The results of these tests are given in the table below, and show that the calorimeter is as accurate as could be hoped for.

The experiments with men have been of two kinds. Rest experiments in which the man did as little muscular exertion as was consistent with comfort; and work experiments, in which he did as large an amount of work as possible for eight hours each day. During the four days preceding an experiment the man eats, sleeps and works just as he expects to do within the chamber. On the evening of the fourth day he enters the chamber and is sealed in. The next morning everything is in readiness for the observations to begin, and the experiment may run from two days to fourteen days.

SUMMARY OF EXPERIMENTS

	NUMBER OF EXPERIMENTS	DURATION	INCOME	OUTGO	PER CENT CALORIES
			CAL.	CAL.	
TEST EXPERIMENTS					
Electrical	5	37 hrs.	3016.3	3016.7	100.01
Alcohol	9	317 hrs.	41703.	41676.	99.93
			CALORIES PER DAY		
WITH MEN					
Rest Experiments	13	45 days	2255	2250	99.8
Work "	6	20 "	3669	3656	99.6
All "	30	93 "	2719	2716	99.9

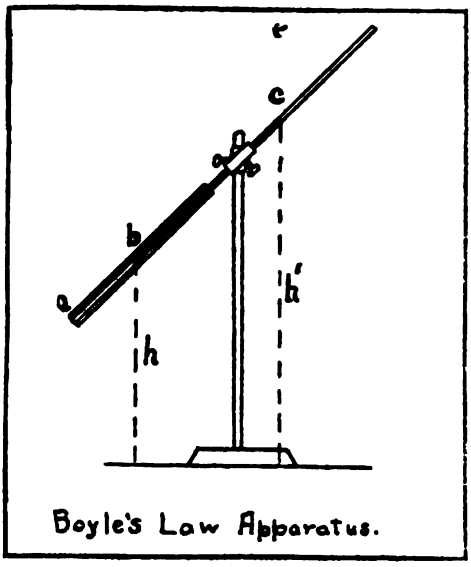
The final results of a large number of experiments are given in the table. In the work experiments the conditions are the most unfavorable for exact results, and all of the experiments are subject to some error, more or less; but since some of the errors will be one way and some the other, the average of a large number will be much nearer the truth than any one. Averaging all of the experiments with men it is seen that the income and outgo of energy balance each other to within the limits of error of the apparatus, that is, to within a small fraction of one per cent. It is therefore safe to say, that, within this small amount, the law of the conservation of energy holds true within the human organism.

MELDE'S APPARATUS FOR BOYLE'S LAW.

C. S. COOKE, CENTRAL HIGH SCHOOL, DETROIT.

In the Report of the Physics Conference for 1899 is described a capillary barometer, and the suggestion was made that the device could be used for verifying Boyle's Law. Just why this feature of the apparatus has never been exploited by some member of the Conference is not apparent. The writer finds that the apparatus herein described is already in use in some high schools, consequently he does not presume to present anything new.

The apparatus needs very little description. A barometer tube about one meter long and 1.5 mm. in diameter is thoroughly cleaned with a solution of bichromate of potash and sulphuric acid. This cleansing solution is



Boyle's Law Apparatus.

followed by distilled water, and finally alcohol is used as a dryer. One end of the tube is carefully sealed in the flame and if only the very end of the tube is heated, it will be sealed nearly square across. The tube is then placed in a suitable clamp and brought to an inclined position of about 45°. An iron wire with about one-quarter of an inch of its end doubled firmly back on itself, is pushed into the tube to about 25 cm. from the closed end. Mercury is then poured through a finely drawn out thistle tube so as to form a column about 30 or 40 cm. long. If the enclosed air column is too long, air can be removed by pushing the wire a little further into the tube. The usual readings for pressure and volume are taken with the tube first in a vertical position and then shifted about 20° each time until the tube is inverted. A paper scale pasted on the tube is used to obtain readings of the

volume, and a meter stick fastened in a vertical position to a suitable base will serve for measurements of the height of mercury column. The table needs to be perfectly level.

a	b	h	h'	h'-h	P	V	PxV
50.00 cm.	61.46 cm.	15.93 cm.	57.28 cm.	41.35 cm.	117.35 cm.	11.46 cm.	1345.
" "	61.65 "	18.00 "	57.55 "	39.55 "	115.55 "	11.65 "	1346.
" "	62.55 "	26.25 "	57.25 "	31.00 "	107.00 "	12.55 "	1343.
" "	64.23 "	37.60 "	56.00 "	18.40 "	94.40 "	14.23 "	1343.
" "	65.70 "	44.70 "	54.50 "	9.80 "	85.80 "	15.70 "	1347.
" "	67.67 "	51.85 "	52.13 "	.28 "	76.28 "	17.67 "	1348.
" "	69.50 "	56.45 "	49.70 "	- 6.75 "	69.25 "	19.50 "	1350.
" "	72.00 "	60.60 "	46.05 "	-14.55 "	61.45 "	22.00 "	1342.
" "	75.20 "	63.50 "	41.00 "	-22.50 "	53.50 "	25.20 "	1347.
" "	79.00 "	64.20 "	34.80 "	-29.40 "	46.60 "	29.00 "	1351.
" "	83.90 "	62.58 "	26.40 "	-36.18 "	39.72 "	33.90 "	1346.
" "	88.85 "	60.40 "	19.23 "	-41.17 "	34.83 "	38.85 "	1353.

The only comment the writer has to make is that the apparatus is exceedingly simple, requires very little mercury, and is easily understood and operated by the pupil. If the tube is carefully selected, there will be no appreciable error due to lack of uniformity of bore. Our pupils readily get results within 1% variation.

COEFFICIENT OF EXPANSION OF AIR UNDER CONSTANT PRESSURE.

E. A. CLEMANS, CENTRAL HIGH SCHOOL, DETROIT.

A few years ago, Mr. N. H. Williams, then of Detroit, presented before this Conference a coefficient of expansion apparatus wherein he used sulphuric acid as a leveling liquid and thus insured the dryness of the enclosed volume of air.

By borrowing this idea and combining it with a modified form of the apparatus described in the preceding paper, we have an efficient means for determining the coefficient of expansion of air under constant pressure.

This apparatus has four qualities that appeal to the physics teacher. It is easy to make, is durable, is simple to operate, and is fairly accurate.

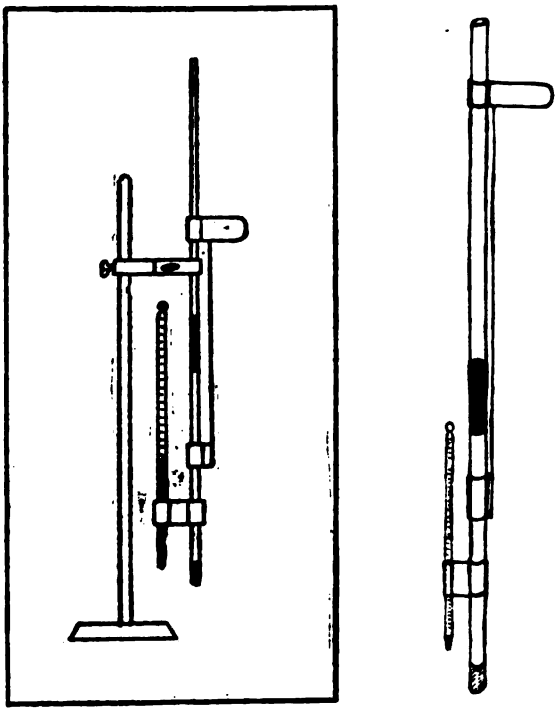
It consists of a capillary tube about two feet long sealed at one end and containing at the closed end a small quantity of sulphuric acid. At about its middle, the tube holds a short thread of mercury. If held in an upright position, the air enclosed between the mercury and the acid will be under a pressure of the atmosphere plus the weight of the thread of mercury and for short periods this may be considered constant.

The volume of the air will then be affected by temperature changes only and the volume at different temperatures may be read in units of length of

the tube. To facilitate this reading I placed on the tube a brass sleeve, fitting just tightly enough so that it could be moved along with a little effort. The position of this sleeve is adjusted by means of a brass rod soldered to it and guided at its upper end by a similar sleeve.

Having placed the tube in a cylinder of water, the edge of the lower sleeve is brought even with the end of the mercury column, the temperature of the water is taken, and the apparatus is removed from the cylinder and clamped in front of a mirrored scale.

The volume of the air is then read. The pupil will adjust the sleeve much more quickly and accurately than he would take a reading. He may



then turn his attention to the reading of the temperature, reading the volume at his leisure and under favorable conditions. A brass bracket may be attached to the tube for holding a thermometer securely and in the immediate neighborhood of the enclosed air.

To get the sulphuric acid to the bottom of the capillary tube, I made a funnel with a long slender tube by heating a piece of large thick glass tubing and drawing it out quickly.

Following is a set of data taken by an advanced student:

TRIAL	TEMPERATURE	VOLUME	INCREASE IN VOLUME	INCREASE PER DEGREE	COEFFICIENT
1	0.	15.80	.....	.....	.....
2	10.	16.38	.58	.0580	.00367
3	19.	16.90	1.1	.0579	.00366
4	53.8	18.88	3.08	.0572	.00362
5	66.	19.58	3.78	.0573	.00363
6	71.3	19.92	4.12	.0579	.00366
7	81.	20.55	4.75	.0586	.00371

REPORT OF THE COMMITTEE ON MATHEMATICS AND PHYSICS.

CHARLES W. BURROWS, CENTRAL HIGH SCHOOL, DETROIT.

The purpose of this report is to call attention to the relations of mathematics to physics, to point out places where these relations are strained, or out of adjustment, and to suggest remedies for whatever evils may exist. It is generally admitted as far as physics and mathematics are concerned, mathematics is the tool and means of attack on a large portion of the problems of physics. If the student is not well grounded and skilful in the use of these tools, his progress is much hampered and the work of science advances under a great handicap. I need not spend much time in proving the proposition that the mathematical training has not produced all that the physicist could desire.

Most of the criticism to which mathematics is open is due to the fact that our work is superficial, not superficial in the sense that each subject is not taught thoroughly, but because it is not taught in its proper relation to life. It appears as an isolated mathematical idea connected by a slender thread to what has preceded and by a still more slender tie to what is to follow in a certain mathematical sequence, but of no moment in the problems of the world. It would be desirable if no new subject were taken up until there was a demand for it, not until it was obvious that the innovation was for the purpose of saving labor or lengthening the intellectual arm so that it might grapple with new problems. Let the pupil feel that new subjects and new methods are as useful in extending his vision in the realm of mathematics as the telescope and microscope have been in other fields of nature. Let him feel that mathematics is the science that puts him in touch with the quantitative in nature, that it is a part of nature itself. If we can do this we have the element of interest on our side, and without this essential we labor in vain as far as any permanent good results are concerned.

To exemplify this idea let us consider the mental condition of our pupils just before they start the study of algebra. The problems of arith-

metic are difficult and if we analyze the difficulty we see that there is in the problem an intangible something which is constantly eluding the pupil. The intangible is freed from this elusiveness as soon as we give it a name, and with the representation of the unknown quantity by X we have made an advance which is obvious to the tyro and as essential to success as was the insertion of the symbol zero in our number system. With this addition and the use of the equation which logically goes with it our pupil finds himself gifted with new powers. Let these powers be exercised on practical problems of increasing difficulty. Let him see by induction that while there are countless problems that may be given him, yet this number may be reduced very materially by a little generalization. He is thus led to the solution of literal equations. In the interpretation of these latter he becomes acquainted with certain formulæ and their values in certain definite numerical problems. If he can transform and substitute in simple literal formula he has about the algebraic facility that is required of the average practical man. The average high school graduate, however, can not use this much mathematics. As soon as this much is understood and before he has a chance to make it a part of himself, he is ushered into new subjects, and these in turn are replaced by others. He completes his course with a certain amount of general training due to his mathematics, but with as little facility in the application of his theories to practical problems as a man who had studied various books on the art of swimming and even had practiced on the floor of his bedroom, would have in breasting the turbulent wave.

In geometry a reasonable amount of intuition might be assumed, *e. g.*, assume "All right angles are equal;" also "If two adjacent angles have their exterior sides in the same straight line, their sum is equal to two right angles," and some other propositions equally as obvious to the student. It is also desirable that the reality of geometry be made evident. Quite often we feel that the mental discipline is not only the main but also the only benefit to be derived from the study of geometry. We lose sight of its vital relations and are satisfied with the beauty of its logic. One pupil who always stood at the head of her class told me she thought geometry was delightful. "You start," said she, "with a few axioms and definitions and build up day by day a glorious structure. Each proposition is a direct result of all that preceded, and you wonder where it all is going to lead eventually." This is, I think, the prevalent view of our best sudents. Geometry is to them as religion is to many people, a thing of the intellect concerned with the future but of no material connection with the affairs of today.

Pure mathematics is an exact science, but applied mathematics deals with approximations. Our students lose sight of this. For instance in getting the circumference of a circle the value $\pi = 3.1416$ is almost invariable used, even though the data may be in error 1%. Results thus obtained are misleading. They should be taught the effect of an error in certain quantities, and taught it early, not in their second year of university work

as at present. It would not be hard to show them that $\pi = 3$ is only 3% out of the way, and $\pi = 3.1$ is 1%, while $\pi = 22/7$ is only 1/30% in error. The value $\pi = 3.1416$ is in error by only .002%, a degree of accuracy realized by no instrument known to me. Then why have our pupils use this value?

Another case that shows lack of feeling for number is the averaging of a column of values nearly equal, as,

24.7
24.4
24.6
24.5
24.7
24.5

The majority will add all three figures of each number and not notice that the variation is in the last figure alone. Further, in such an example as the above it is not unusual to have an average reported which is beyond the range of the given values. The pupil does not feel the relation between the average and the individual numbers.

Again, in multiplication and division results are obtained, in which a misplaced decimal point makes the final result of an order of magnitude quite different from what we know it to be. Such things as these should appear as incongruous to the pupil as would a man in midsummer heavily muffled in furs. I have said nothing about division by 10 by the long method, or multiplication by 12 in two steps, but have cited just a few cases to show that quantitative relations are vague to the average student.

One criticism I make against the problems commonly found in our modern text-books is the lack of reality. I shall cite just a few. Here is one taken from a leading text-book of algebra. "A shepherd has a number of sheep such that 4 times the number minus 7 is greater than 6 times the number minus 89, and 5 times the number plus 3 is greater than twice the number plus 114. How many sheep has he?" It is hard to show the student that this problem has any application other than to keep him busy. Here is another impracticable one in the form of an equation:

$$\sqrt{a \div x} + \sqrt{a - x} = \sqrt{x}.$$

The answers given by the author and obtained in the regular way are 0 and $4a/5$, both of these roots are extraneous, as is easily seen yet nothing is said about this. Such problems as these, and they are not rare, tend to shake what little confidence our pupils may have in either the utility or the reliability of mathematics.

This report would be incomplete without a few comments on the laboratory method. Let me translate a paragraph written by Laisant in his work La Mathématique: "All science is experimental. Nothing enters our understanding without having passed under the view of our perceptions. Mathematics no more than any other science can escape this common law. I believe that without the presence of the external world no mathematical knowledge could ever penetrate the brain of man, and that

in a universe reduced to the condition of pure intelligence, the most incomparable genius, whether it be an Archimedes, a Gauss, or a Lagrange could never arrive at the conception of the number two."

While we all regret that laboratory work of some kind is desirable, there is considerable doubt as to what to include. I wish right here to register a protest against setting up a preliminary physical laboratory and calling it mathematics. This only makes matters worse for the physics. It robs the physics of its charm of novelty and does not overcome the mathematical difficulties. What we need is an opportunity to verify and investigate the truths relating to magnitudes, and to attain facility in the use of mathematical instruments whether they be mental or mechanical, just as in the physical laboratory we verify and investigate physical laws and aim to attain facility in the use of physical instruments. Since the work of the mathematical laboratory would deal with lengths, areas, and volumes, as well as pure numbers, it might well contain most of the following pieces of apparatus. I merely enumerate them without taking time for comment:

Measurements of lengths.
- 2-foot rule
- yard stick
- 50-foot tape
- vernier calipers
- micrometer guage
- chartometer

Measure of area.
- section paper
- planimeter

Measure of volume.
- U. S. liquor measure
- metric set

Measure of angles.
- protractors
- scale of chords
- engineer's transit
- architect's level
- spherometer

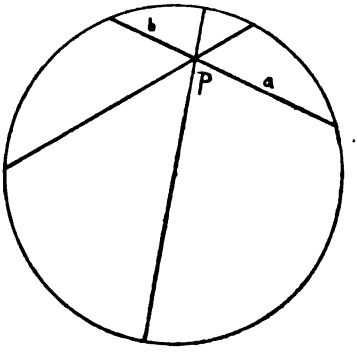
Aids to computation.
- slide rule
- carpenter's square
- mathematical sector
- mathematical tables

Miscellaneous.
- scale rule
- proportional dividers
- drawing set
- plans of buildings

Much of the work that is done in arithmetic could be done as laboratory working algebra. Pains should be taken here to make the work practical. When the theory of exponents is taken up is a good time to introduce the use of logarithms and the slide rule in elementary calculations. They are both so closely connected with the theory of exponents that no extra time will be needed, that is, on the assumption that the theory of exponents is to be made real.

The laboratory work in geometry would consist of the construction with great accuracy of figures and the verification by actual measurement that the proposition is true. Again, geometrical truths could be arrived at inductively. To make my meaning clear I will state a few individual cases. There is a large class of problems in which it is proved that the product of two variables is a constant. The proper understanding of these is a first class mathematical preparation for the study of Boyle's Law. Of this class, is the following: "If two chords be drawn through a fixed point within a circle, the product of the segments of one chord is equal to the product of the segments of the other." The data could be arranged as follows:

a	b	ab



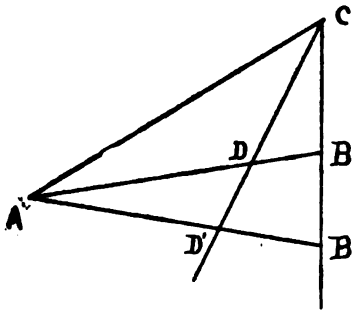
Pass various lines through P and measure accurately the lengths a and b and record in the tabuler form. The constant product in the last column will impress the fact fully as much as the rigid demonstration. If in addition to this a curve is plotted having a and b for coordinates, the exercise is complete and the proposition is seen in all its dimensions due to the added perspective.

Another large class of geometric problems is that which is analogous to Hooke's Law. An example of this class is the following: "In any triangle the bisector of an angle divides the opposite side into segments proportional to the adjacent sides." The data for this experiment may be tabulated as below:

This data is obtained by drawing various lines AB, A′ B′, etc., and measuring accurately the corresponding lines.

A third type of work suitable to the laboratory is the determination of geometrical constants, such as the value of and a radian. For such work as this the chartometer and the planimeter would be very valuable. Squared paper could be used with considerable accuracy. By the use of such paper I determined the value of π to .1% which is sufficiently accurate for all practical purposes.

There are some problems whose truth would be but vaguely realized unless supplemented by experimental verification. Such a one is the following: "In any triangle the square of the side opposite an acute angle is equal to the sum of the squares of the other two sides minus twice the product of one of these sides and the projection of the other upon it." From the previous experiment the details of this one are obvious.



AC	BC	AC/BC	AD	BD	AD/BD

This work would give a good opportunity to study the effects of errors in measurement. Suppose the two quantities to be measured are multiplied together and that 4 and 7 is one pair of values. The product is 28. Suppose that there is an allowable error of .5 in each measurement. This will give us for our product $4.5 \times 7.5 = 33.75$, or an error in the product of 5.75, which is 20%. This readily admits of generalization.

There should be at least one double period per week for the laboratory work which should be carried on in connection with every course offered in mathematics. In algebra and geometry perhaps not so many original exercises could be done, but what was done would be more thoroughly understood and retained. If the laboratory work crowds the student I would suggest the omission of partial fractions, series, progressions, quadratic surds, imaginaries, and some other things that are not needed in elementary mathematics or for general practical purposes.

THE ALGEBRAIC EQUATIONS OF LISSAJOUS'S CURVES.

G. E. MARSH, S.B., CASE SCHOOL OF APPLIED SCIENCE.

The curves of Lissajous though probably known to the scientific world of the eighteenth century were first studied by Nathaniel Bowditch in 1815 in connection with the motion of a pendulum suspended from two points.[1]

The algebraic equations of the curves resulting from the combinations of the two or three simplest period ratios have been known for some years though the equations of curves of all higher orders have resisted all previous

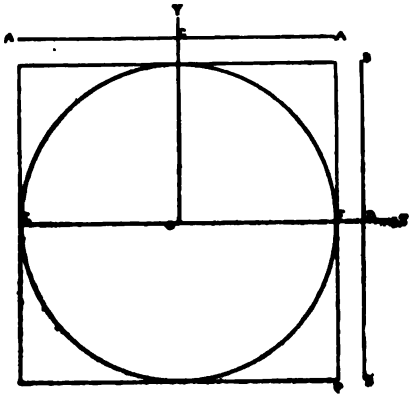


FIG. I.

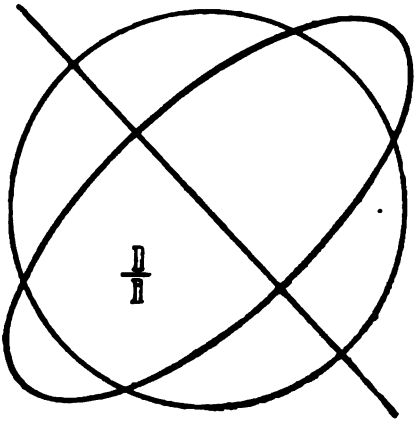


FIG. II.

efforts made toward expressing them algebraically, and on this point P. G. Tait in his article on Mechanics in the Encyclopedia Britannica asserts the impossibility of their being so expressed.

The two coplanar, simple harmonic motions, conceived as taking place in the lines AA′ and BB′ of the diagram, Fig. I., may be represented by the equations

$$x = a \cos\left(\frac{2\pi t}{T_1} + E_1\right), \qquad (1)$$

$$y = b \cos\left(\frac{2\pi t}{T_2} + E_2\right),$$

where the epochs are E_1 and E_2 and a, b and T_1, T_2 are the amplitudes and per-

[1]Memoirs of the American Academy, 1815. This was more than thirty-five years before Lissajous brought them to notice. It is an unfortunate circumstance that they do not bear the name of our illustrious American mathmatician.

iods respectively of the two motions. If n_1 and n_2 are the frequencies, the equations may be written in the equally familiar form

$$x = a \cos (2 \pi n_1 t + E_1), \qquad (2)$$
$$y = b \cos (2 \pi n_2 t + E_2).$$

Since the initial difference in phase of the two motions, that is, when $t = o$, is the difference of the epochs, the last equations give

$$x = a \cos (2 \pi n_1 t + E), \qquad (3)$$
$$y = b \cos (2 \pi n_2 t),$$

if $E = (E_1 - E_2)$.

Two methods for the elimination of the variable t are clearly possible. (1). By introducing trigonometric values of t from the second into the first. (2). By expressing t explicitly in each equation and equating values thus obtained.

Considering the first method, the elimination of t from Eqs. (3) may be accomplished by expanding the value of x and introducing the value of the

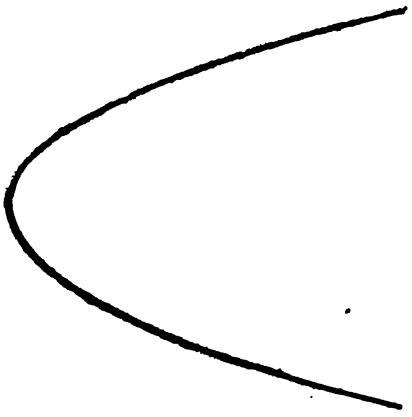


FIG. III.

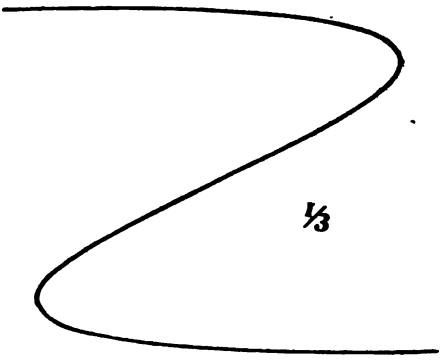


FIG. IV.

sin and cos terms obtained from the second equation. This demands that the terms in the expansion of the first equation shall be derivable from the second equation.

If $\frac{n_1}{n_2} = \frac{n}{1}$ where n is an integer, there is no difficulty involved in the process as the terms in the expansion of x may be expressed in terms of those of the first degree which is exactly the nature of those to be obtained from the second equation.

If the frequency of ratio is not an integer, the elimination is more difficult and possible only in a few cases at the most.

From (3)

$$x = a\left(\cos 2\pi n_1 t \cos E - \sin 2\pi n_1 t \sin E\right),$$

$$= a\left(\cos E\,[A] - \sin E\,[B]\right),$$

where A and B are the proper finite series for the expansions of $\cos 2\pi n_1 t$ and $\sin 2\pi n_1 t$ respectively in terms of $\sin 2\pi t$ in the first case and $\cos 2\pi t$ in the second. Making use of the same general series, the value of y may

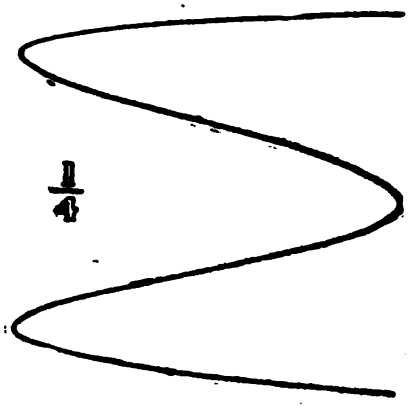


FIG V.

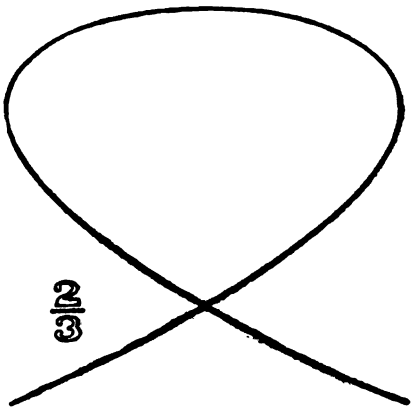


FIG VI.

be likewise expressed as an expansion in terms of powers of $\sin 2\pi t$ and $\cos 2\pi t$ as in the case of x. Even if n_1 and n_2 are small integers this method of elimination is accompanied with so large an amount of work, that of freeing the two series, composed of power terms of $\sin 2\pi t$ and $\cos 2\pi t$, of t as well as afterwards reducing results to convenient form, that there is but little merit in it. And for values of n greater than 3 the method fails completely.

Since the present paper was delivered Mr. E. B. Escott, of the University of Michigan, has called my attention to the solution of Eqs. (3) through the use of exponential imaginaries for the expression of the trigonometric terms. The method is neat though considerably longer and lacks the generality of the present one.

Returning now to the second method of elimination, there results from Eqs. (2),

$$t = 2\pi\frac{1}{n_1}\left(\cos^{-1}\frac{x}{a} - E_1\right)$$

$$t = 2\pi\frac{1}{n_2}\left(\cos^{-1}\frac{y}{b} - E_2\right)$$

$$\therefore \left(n_2 \cos^{-1}\frac{x}{a} - n_1 \cos^{-1}\frac{y}{b}\right) = n_2 E_1 - n_1 E_2 = C. \qquad (4)$$

By trigonometry

$$\cos n\theta = 2^{n-1}\cos^n\theta - n \cdot 2^{n-3}\cos^{n-2}\theta + n\frac{n-3}{2}2^{n-5}\cos\theta^{-4} - \ldots \quad (5)$$

where the Rth or general term is,

$$(-1)^{r-1}\, n\,(n-r)^{n-r-1} \ldots\ldots (n-2r+3)\, 2^{n-2r+1}\cos\theta^{n-2r+2},$$

and $$(-1)^{\frac{n}{2}} \frac{n\left(\frac{n-2}{2}\right)\left(\frac{n-4}{2}\right)\left(\frac{n-6}{2}\right) \ldots\ldots\ldots 1}{\left(2-\frac{n}{2}\right)!},$$

or $$(-1)^{\frac{n-1}{2}} \frac{n\left(\frac{n-1}{2}\right)\left(\frac{n-3}{2}\right) \ldots\ldots 2\cdot 1\cdot\cos\theta}{\left(\frac{n-1}{2}\right)!},$$

is the last term depending on whether n is even or odd. The number of terms in the expansion (5) is $\left(\frac{n+2}{2}\right)$ if n be even, and $\left(\frac{n+1}{2}\right)$ if n be odd.

Placing $\cos\theta = m$, Eq. (5) becomes

$$n\cos^{-1}m = \cos^{-1}\left(2^{n-1}m^n - n2^{n-3}m^{n-2} + n\frac{n-3}{2}2^{n-5}m^{n-4} \ldots\right) = \cos^{-1}(M), \quad (6)$$

provided M be taken to represent the series in the parenthesis.

The quantities M corresponding to the first ten values of n are as follows (by expansion (6)):

$$\left.\begin{aligned}
\cos^{-1}m &= \cos^{-1}(m)\\
2\cos^{-1}m &= \cos^{-1}(2m^2-1)\\
3\cos^{-1}m &= \cos^{-1}(4m^3-3m)\\
4\cos^{-1}m &= \cos^{-1}(8m^4-8m^2+1)\\
5\cos^{-1}m &= \cos^{-1}(16m^5-20m^3+5m)\\
6\cos^{-1}m &= \cos^{-1}(32m^6-48m^4+18m^2-1)\\
7\cos^{-1}m &= \cos^{-1}(64m^7-112m^5+56m^3-7m)\\
8\cos^{-1}m &= \cos^{-1}(128m^8-256m^6+160m^4-32m^2+1)\\
9\cos^{-1}m &= \cos^{-1}(256m^9-576m^7+432m^5-240m^3+9m)\\
10\cos^{-1}m &= \cos^{-1}(512m^{10}-1280m^8+2120m^6-400m^4+8m^2-1)
\end{aligned}\right\} (6^2)$$

Applying Eq. (6) to Eq. (4) we have

$$\cos^{-1}M_x - \cos^{-1}M_y = C, \qquad (7)$$

where M_x and M_y are the expansions of $n_1\cos^{-1}\frac{n}{a}$ and $n_2\cos^{-1}\frac{y}{b}$ respectively by Eq. (6) or from (6^2).

By means of the relation

$$\cos^{-1} g - \cos^{-1} h = \cos^{-1} (gh + \sqrt{1 - g^2}\sqrt{1 - h^2}),$$

which is another form of

$$\cos (x - y) = \cos n \cos y + \sin x \text{ and } y, \text{ if}$$

$$\cos x = g,$$
$$\cos y = h.$$

Eq. (7) becomes

$$\cos C = M_x M_y + \sqrt{(1 - M_x^2)}\sqrt{(1 - M_y^2)},$$

or

$$M_x = M_y \cos C \pm \sqrt{1 - M_y^2} \cdot \sin C. \tag{8}$$

Equation (8) is a general algebraic equation for all curves compounded of two coplanar, S. H. M. at right angles, of whatever amplitudes, periods

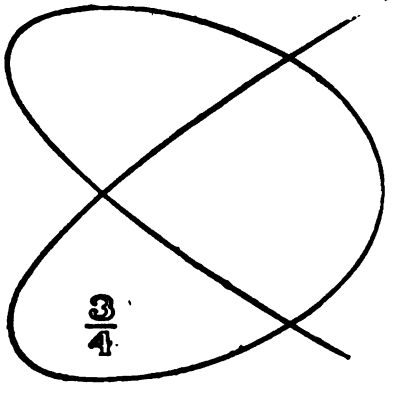


FIG. VII.

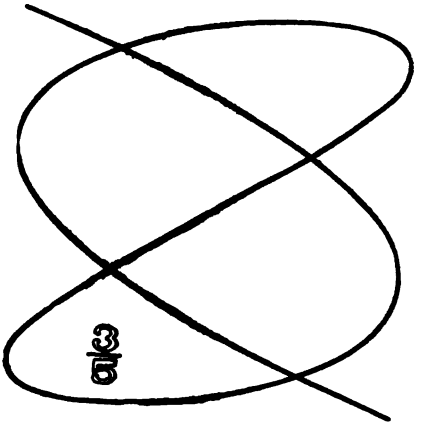


FIG. VIII.

and phase relations. The equation, furthermore, is in no sense transcedental as the trigonometric terms or phase constants are by their very nature Eq. (4), completely determined when the epochs and periods are given, and which are obviously essential for the specification of any particular curve.

If the epochs are zero, or if C = o, Eq. (8), reduces to the beautifully simple form

$$M_x = M_y, \tag{9}$$

a relation which enables the equation of the curve to be written immediately by merely taking the values of M_x and M_y from the Eqs. (6^2).

If $C = \frac{\pi}{2}$ or $\frac{3\pi}{2}$ Eq. (8) again takes an attractive form though by no means as simple as the one just given.

$$M_x^2 + M_y^2 = 1. \qquad (10)$$

It is interesting to note also that in the values of M for odd values of n there is no constant term, none not involving m, accordingly Eq. (9) will be

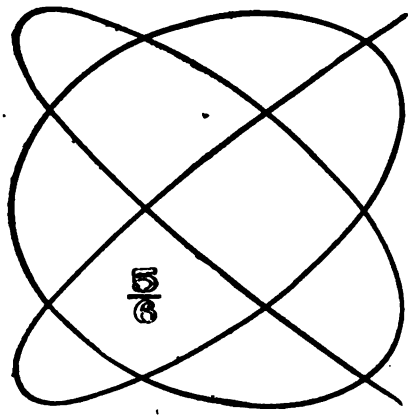


FIG. IX.

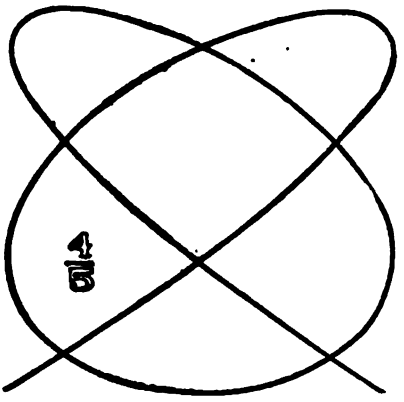


FIG. X.

that of a curve passing through the origin when n_1 and n_2 are each odd integers, and this irrespective of the values which the amplitudes may have.

It will now be interesting to consider the equations of the curves compounded of two simple harmonic motions whose frequencies are those of concords which constitute the diatonic scale.

1) When $n_1 = n_2$; the curve is that known as a perfect unison.

Eq. (8) gives with the aid of (6^2), since in every case $m_x = \frac{x}{a}$ and $m_y = \frac{y}{b}$

$$\frac{x}{a} = \frac{y}{b}\cos C \pm \sqrt{1 - \frac{y^2}{b^2}} \cdot \sin C,$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}\cos C = C \sin,$$

which is, in general, the equation of an ellipse.

If $C = 0$, or π,

$$\frac{x^2}{a^2} \pm \frac{2xy}{ab} + \frac{y^2}{b^2} = 0,$$

or

$$\left(\frac{x}{a} \pm \frac{y}{b}\right)^2 = 0,$$

which represents pairs of coincident straight lines through the origin and making angles with the axes which are easily determined from the equations.

If $C = \frac{\pi}{2}$, or $\frac{3\pi}{2}$,

$$\frac{x^2}{a^2} + \frac{y_2}{b^2} = 1,$$

an ellipse, which readily gives the circle $x^2 + y^2 = a^2$ when the amplitudes become equal.

2) If $\frac{n_1}{n_2} = \frac{2}{1}$, the curve represents the octave.

Eq. (8) becomes

$$\frac{x}{a} = \left(\frac{2y^2}{b^2} - 1\right) \cos C \pm \sqrt{1 - \left(\frac{2y^2}{b^2} - 1\right)^2} \cdot \sin C$$

$$\text{If } C = 0, \qquad y^2 = \frac{b^2}{a} x + 1,$$

which is the equation of a parabola.

$$\text{If } C = \frac{\pi}{2}, \qquad b^2x^2 = 4a^2y^2 (b^2 - y^2),$$

which represents a curve of the figure eight type.

3) When $\frac{n_1}{n_2} = \frac{1}{3}$ and $C^2 0$,

Eq. (9) gives

$$\frac{x}{a} = 4 \frac{y^3}{b^3} - 3 \frac{y}{b}.$$

4) When $\frac{n_1}{n_2} = \frac{1}{4}$, we have the double octave.

Eq. (9) gives, if $C = 0$,

$$\frac{x}{a} = 8 \frac{y^4}{b^4} - 8 \frac{y^2}{b^2} + 1.$$

5) When $\frac{n_1}{n^2} = \frac{3}{2}$, representing the fifth,

If $C = 0$, Eq. (9) gives,

$$(2x^2 - a^2) b^3 = (4y^3 - 3b^2y) a^2,$$

which reduces to, if the amplitudes be equal,

$$x = \pm \sqrt{\frac{4y^3 - 3a^2y + a^3}{2a}}.$$

6) When $\frac{n_1}{n_2} = \frac{4}{3}$, representing the fourth,

If C = o. Eq. (9) gives

$$(4x^3 - 3a^2x)\, b^4 = (8y^4 - 8y^2b^2 + b^4)\, a^2.$$

7) When $\frac{n_1}{n_2} = \frac{5}{3}$, a major sixth.

If C = o, $4\,\frac{x^3}{a^3} - 3\,\frac{x}{a} = 16\,\frac{y^5}{b^5} - 20\,\frac{y^3}{b^3} + 5\,\frac{y}{b}$,

evidently a curve passing through the origin.

If the amplitudes be equal we get a somewhat simpler expression,

$$4a^2x^3 - 3a^4x = 16y^5 - 20a^2y^3 + 5a^4y.$$

8) When $\frac{n_1}{n_2} = \frac{6}{5}$, a minor third.

$$C = o, \quad 16\frac{x^5}{a^5} - 20\frac{x^3}{a^3} + 5\,\frac{x}{a} = 32\,\frac{y^6}{b^6} - 48\,\frac{y^4}{b^4} + 18\,\frac{y^2}{b^2} - 1$$

$$(16x^5 - 20a^2x^3 + 5a^4x)\, b^6 = (32y^6 - 48b^2y^2 + 18b^4y^2 - b^6)\, a^5$$

9) When $\frac{n_1}{n_2} = \frac{5}{4}$, a major third.

$$C = o, \quad (8x^4 - 8a^2x^2 + a^4)\, b^5 = (16y^5 - 20b^2y^3 + 5b^5y)\, a^4$$

10) When $\frac{n_1}{n_2} = \frac{9}{8}$, C = o.

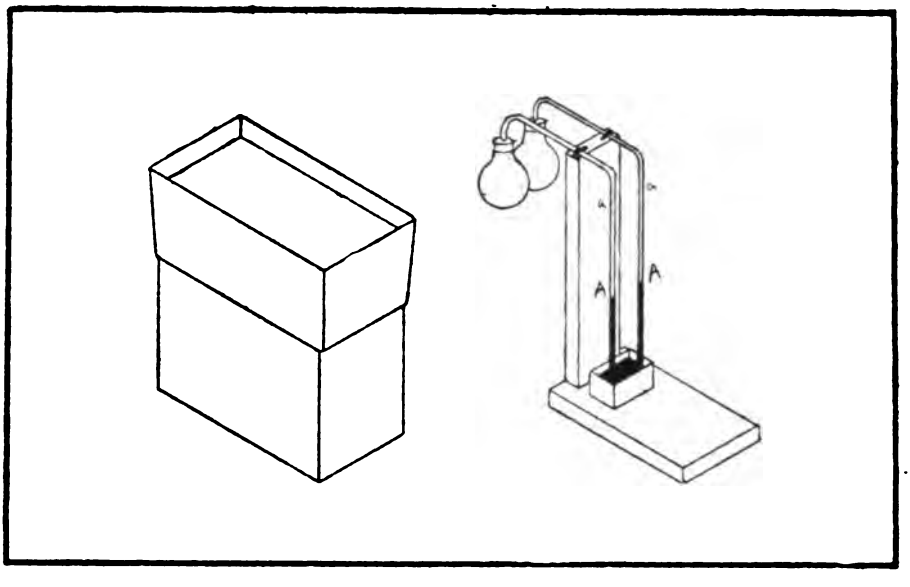
Eq. (9) gives

$$(128x^8 - 256x^6a^2 + 160a^4x^4 - 32a^6x^2 + a^8)\, b^9 =$$
$$(256y^9 - 576y^7b^2 + 432y^5b^4 - 240y^3b^6 + 9yb^8)\, a^8$$

AN APPARATUS FOR ILLUSTRATING THE EQUALITY OF EXPANSION OF DIFFERENT CASES

C. F. ADAMS, CENTRAL HIGH SCHOOL, DETROIT, MICH.

The apparatus here described is intended to illustrate before a class that different gases expand equally under similar conditions. It consists essentially of two air-thermometers of equal size supported upon a wooden standard, as shown in Fig. 1. The bulbs of these thermometers are two small flasks of about 100 c.c. capacity. The capacities of these flasks were first tested to see that they were equal and marks made upon their necks with a file to show how far the stoppers should be inserted to maintain the equality.



About 3 c.c. of sulphuric acid are placed in each flask to keep the gases dry. The vertical part of the stems of the thermometers, AA, consists of a small slim pipette or burette graduated in tenths of a cubic centimeter from 0 to 5 c.c. They were selected so that the lengths of the graduated parts are equal and the zero marks equally distant from the end. These pipettes, inverted, are connected to the flasks by glass tubing bent as shown in the figure. The union at *aa* may be made by rubber tubing, but it is an easy matter to fuse the pipettes to the tubing and the apparatus is more permanent and there is less danger of leakage. Care should be taken to have the bottoms of the two flasks at the same level and the lower ends of the pipettes should also be at the same level. These dip into a beaker containing cencen-

trated sulphuric acid. Commercial acid should be used since it can be easily seen in the tubes at a distance.

The flasks are closed by stoppers having two holes. After the apparatus is set up one of the flasks is filled with hydrogen or other gas by inserting a delivery tube of a gas generator in one of the holes of the stopper and gas passed through until all of the air is expelled. The hole in the stopper is then closed with a glass plug. The other flask is filled with air. The chief difficulty in setting up the apparatus is in making it perfectly air-tight.

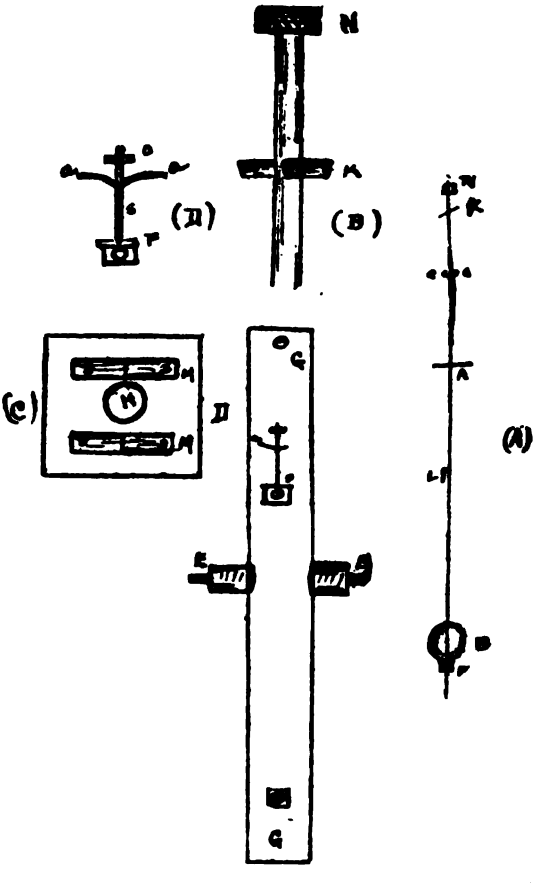
In using it a large basin of water is placed upon a box (Fig. 2) at such a height that when the flasks are placed in it and the wooden support rests on the table, the flasks do not quite touch the bottom of the basin. The support should be heavy enough to hold the flasks down in the water. Before the apparatus is used the flasks should be placed in water about 10° warmer than will be used in the class room, say about 45° C, thus some of the gases will be expelled so that at about 20° C, the acid will stand near the top of the graduation in the stems of the thermometers. For the actual experiment it is best to have two basins, one containing water at about 20°C and the other water at about 35° C. The flasks can then be placed alternately in one basin and then in the other, and the expansion and contraction noted. It will be readily seen that the experiment will take very little time in the class and that it can be repeated with very little trouble.

AN ELECTRICAL PENDULUM FOR SIGNAL SERVICE IN LABORATORIES.

W. H. HAWKES, ANN ARBOR.

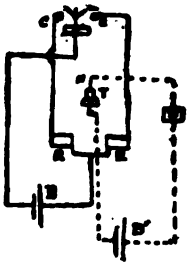
The electrical pendulum described here is offered as an instrument for giving time signals in laboratories where such experiments are made, and especially in laboratories where the expensive laboratory clock is not available. After a test running over several months this apparatus has shown itself perfectly reliable as a time keeper, any variation in its time of vibration during that time not being apparent. It is operated by a current from a single Daniell cell, this cell being chosen on account of the constancy of the current it maintains. In circuit with the battery are two electro-magnets that are alternately thrown in and out of the circuit by a little device that is the secret of the success of the pendulum. The nature of the device is that of a swinging contact key, that closes the circuit automatically on the approach of the pendulum to either electro-magnet, but at the instant of the return of pendulum the contact is broken and the pendulum swings back free, toward the other electro-magnet, till at the most effective distance from it, the circuit closes through the other electro-magnet, this in turn demagnetizes at the return of the swing, and so the uniform motion of the pendu-

lum is maintained. The pendulum carries the armature that oscillates back and forth between the electro-magnets, and upon which the magnetic pull is exerted. The construction of such a pendulum is quite within the limits of the amateur mechanic. Provide a rod of brass or wood, preferably wood, as it is less susceptable to changes in temperature, with a bob of about 8 pounds weight, with adjusting screws beneath as in Fig. A. Mount on this rod armature at A, needle for mercury contact at L. Platinum tip terminals for contact in closing the circuit through a and a' as the pendu-



lum swings (Fig. D). The pendulum may be hung by the conventional spring lug at the end or if the rod is brass a piece of file (k, Fig. B) smoothed to an edge is soldered into a slit cut in the rod and the pendulum passed through the hole H (Fig C) swings with the sharp edge resting on the brass strips M M screwed to the shelf D. The adjusting screw, N (Fig B), may then be used for a fine adjusting of the pendulum for

accurate time vibration. The pendulum thus fitted is hung on the board, G, screwed to the wall. The swinging contact a. a. that closes the circuit through the electro-magnets is constructed by taking a piece of brass, s, about 1-16 inch in diameter and two inches long, pointing the lower end; a thin piece of brass or copper is soldered on to this shaft as shown in the cut (D). This is then mounted with the point P resting on a brass shelf and the upper end lightly strapped to the board at O. The electro-magnets E, E, are made of No. 20 cu wire and are about 1½ inches in length by 1 inch in diameter, the cores extending about ½ inch beyond the end of the helix, for greater strength of magnetism and convenience. These electro-magnets are fastened on some convenient support about ⅓ the distance down from the point of suspension of the pendulum to the bob. These are connected in a double circuit system with the Daniell cell as shown below. The diagram also gives the connections for mercury contact in the sounder circuit.



PENDULUM CIRCUIT.

cc = Contacts on Pendulum.
aa = Swinging Contacts.
EE = Electro-magnets.
B = Battery (Daniell).

SOUNDER CIRCUIT.

T = Mercury Contact.
N = Needle, or Pendulum.
S = Sounder.
B′ = Battery (Leclanche).

THE PURIFICATION OF MERCURY

W. H. HAWKES, ANN ARBOR.

Clean mercury is a laboratory essential and the ease with which mercury becomes impure makes a stock of clean mercury hard to keep. The method of distillation is difficult and tedious of operation without special and expensive apparatus and is attended with considerable loss of both mercury and time.

The following method will save all this and will enable laboratories to keep their stock of mercury clean and in good condition ready for use when needed.

Provide a cylindrical jar 20 cm. long by 3 cm. diameter, a stick of common electric light carbon (without copper coating), a Sprengels air pump (aspirator), rubber tubing, two-hole rubber stopper for the jar, one and one-half feet of glass tubing of proper size for the stopper.

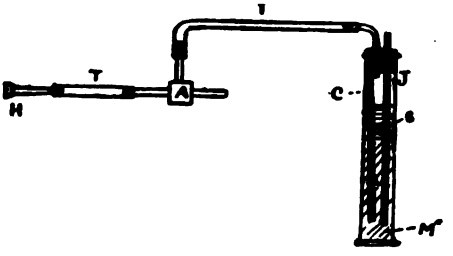
Cut the glass tubing into two pieces, one piece long enough to reach

nearly to the bottom of the jar, extending through the stopper about one inch. Bend the remaining piece into an L-shape, inserting the short arm through the stopper about one inch. Connect the aspirator by proper-sized rubber tubing and the water faucet; to do this it may be necessary to use a reducer joint to fit the tubing, that may be obtained of the plumber. Connect the other end of the aspirator to the outer end of the L tube. The apparatus is now ready for use.

The process of cleaning is briefly described as follows:

Fill the jar a little more than half full of the mercury to be cleaned. Pour in on top of this dilute H_2SO_4 (1-8) to the depth of about 1½ inches. Insert a rubber stopper having no perforation and rock the mercury back and forth through the acid, bringing the mercury well in contact with acid. Take out the stopper and insert the stick of carbon reaching nearly to the bottom of the jar; insert the stopper with the tubes; turn on the water until the air bubbles up through the mass of mercury freely. Allow this process to continue from 20 min. to half an hour, according to the condition of the mercury. If the mercury is very dirty, pour off the acid and put in some fresh and continue the process 15 or 20 minutes longer. Then pour off acid. Wash the mercury thoroughly in clean water until there is no trace of acid in it; then dry it by thrusting filter paper into it. Finally filter into a clean

DIAGRAM SHOWING ARRANGEMENT OF PARTS.



H=FAUCET
TT=CONNECTING TUBES
A=ASPIRATOR
J=JAR
M=MERCURY
S=ELECTROLYTE
C=CARBON

vessel and the process is complete. If the work is properly done there will not be the trace of a film upon its surface, nor will it leave any stain or trail on porcelain. The process requires no attention while the purification is going on, no expense except that invested in the apparatus, and practically no loss of mercury.

The process of purification involved is electrolytic. The impurities in the mercury, acting as one electrode while the carbon acts as the other, the electrolyte being the acid. The object of the aspirator is to keep the mass well agitated, bringing the surface of the Hg. constantly in contact with the acid and carbon, with a slight oxidizing process attending the passage of the air through the mercury. In the process the impurities of the mercury go into solution and of course is washed out afterward. If the mercury is decidedly greasy or oily, use caustic potash instead of H_2SO_4 leaving out the carbon, washing and drying in the same manner as above.

It will quicken the process to filter the mercury before subjecting it to the process above described; in fact, filtration will often take out all the coarser impurities that only interfere with its use for certain experiments.

The accompanying diagram will assist in setting up the apparatus.

BIOLOGICAL CONFERENCE AND SCIENCE TEACHING

AIMS AND METHODS IN ELEMENTARY FIELD WORK.

I. B. MEYERS, THE UNIVERSITY OF CHICAGO SCHOOL OF EDUCATION.

In outlining this paper I have confined myself to the beginning or elementary phases of field work. My effort is to indicate a line of progression rather than attempt to go into details as to methods of procedure. This paper is controlled by the thought that the pupil is a greater consideration, at this stage of school work, than the subject.

We may recognize two fairly distinct stages in field work—(1) A stage when the pupil is largely dominated by the pleasure he derives from physical activity, seeing new things, gaining new sense experiences, acquiring skill, satisfying his restless and insatiable curiosity. This is the very elementary stage, and may be termed a period of radiation. It is a period not very fully recognized by our courses of study and one for which they have not well provided. (2) The second stage is the period when the pupil through special aptitude or experience develops dominating interest in some special phase of study and confines himself largely to a particular subject—this marks the beginnings of specialized work. There are all gradations between these two phases. It is important that we consider whether the character of the work of pupils during this *period of radiation* has any positive value in case the student never reaches the period of specialized work and second whether it prepares him for the more specialized work of later school life; in so far as it fails in either of these two ends it must be considered insufficient and in so far as it fulfills these two conditions it must be considered efficient and practicable. In this process of educating there are two prime considerations (1) the various phases of knowledge which have been accumulated, sorted, and systematized, and given a position in the course of study—physiography, botany, zoology; (2) the human being known as the pupil. The process of educating is conceded to be through some interrelation of subject with pupil or pupil with subject, and it is our view point as to the nature of this interrelation that is the crucial thing in our "aims and methods of teaching."

Either these subjects which make up the course of study are selected as types of knowledge to be learned by the pupils; the amount learned being

the measure of educational progress; *or* they represent types of knowledge to be used in developing desired qualities of physique, mentality, skill and working efficiency, the power gained in these directions *being the measure of educational progress.* The distinction may not always appear clear cut or essential but the path of school progress is strewn with the wrecks of methods which were founded upon the conception that the function of teaching is wholly concerned with inducing pupils to learn the subject, and the methods have ranged from that of Gad Grinds through all types of pedagogical novelties which were warranted to induce, lead or trick, the pupil into learning the desired subject. There exists, however, a growing belief that the subject may be so taught that the act of learning will prove to be the vital factor in education; a belief that the pupils' interests may form a basis for educational procedure and progress.

However well we may have formulated and stated the laws which relate to individual experience and self activity and however strong our belief in them as the fundamental basis of human development, we must admit that the application of these principles has not been a controlling factor in educational practice. If we can find a type of school work rich in a subject which appeals to the instincts and interests of the pupils, and which at the same time offers exceptional opportunities for individual initiative and self effort; then I believe that in the use of this subject the problem of individual development and the problem of knowledge of the subject are on a fair way to complete solution, the two things will prove to be interdependent.

Gaining an acquaintance with the sciences through field work must surely have quite a different influence upon the student from that of the text-book and laboratory method, especially when his field experiences are supplemented by related reading and experiment.

It is the function of elementary field work to recognize and give more freedom to the natural instincts and interests of students and by so doing beget in the students, through personal contact, a familiarity with nature and her ways. The keynote of the work is individual interest and effort, the crucial point, pedagogically, is that the interest and mental movement aroused by this direct contact shall not be smothered by the text and the teachers descriptions. These should be strong aids in enlarging and intensifying this mental movement but the teacher should be careful not to divert or dominate it. "The facts of science have been so abundantly acquired, so thoroughly systematized, and rendered so easily available through text-books, manuals and models that we frequently resort to the teachings of these schemes of knowledge instead of the knowledge itself."

Field work brings the pupil in contact with materials and phenomena which, through sense experience, investigation, and inference, he converts into knowledge. The value of this field work is very largely determined by the way we use it and what we expect to gain through this use. One of the mistakes of field work is the practice of using it to supplement or illustrate our indoor class work; this is better than no field work, but I do not believe that it is the best use.

This leads to a habit of trying to fit facts to theory, rather than formulating inferences and theories out of observed facts. It is the experiences, materials and thoughts of the field which should be brought to the class room and form the basis for the recitation, for reading, and experimentation. The problem is whether, at this beginning stage of science, the text and manual shall be centers for student effort or whether the out-of-door environment shall be the center and the text, manual, and laboratory constitute the aids to the study; whether the field shall supplement the indoor equipment or whether the indoor equipment shall supplement the field work.

Field Work.—The materils with which pupils come in contact in field work may be grouped under the heads of (1) Climatology, (2) Physiography, (3) Mineralogy, (4) Botany, (5) Zoology. In our text-books these constitute distinct sciences and are treated separately; in the field we find them intimately interrelated.

There comes a time, very soon, however, when it is desirable that this work take on something of the spirit of conscious purpose and study.

In the School of Education we have found the school garden a most fertile aid in this transition. The idea of planting is readily grasped, this working with the soil, handling tools, digging and planting appeals strongly to the pupils' instinct of workmanship.

With a definite purpose in mind and a certain impatience to set to work, the pupil faces a whole series of new problems. He begins to grasp the idea that in raising plants results depend largely upon the fulfillment of certain conditions. He must gain information as to time of planting, preparation of the soil, depth and distribution of seeds, care of plants.

Going hand in hand with the work are a series of problems which spring directly from the garden work:

1. A study of the various ways in which new growths arise, seeds, bulbs, tubers, cuttings, etc.
2. Conditions essential to start new growths,—temperature, moisture.
3. Advantage of placing seeds in ground.
   (a) Uniform moisture conditions.
   (b) More uniform temperature.
   (c) Depth of planting.
4. Amount of moisture absorbed by seeds to start germination.
5. Amount of moisture in given volume of soil.
6. How this moisture reaches the seed and plant.
7. Amount of moisture required in various soils to support various plants.
8. Weeds and cultivated plants—why weeds can overcome cultivated plants.
9. Light and plant growth—purpose of weeding—green of plants.
10. Nature and origin of soil.
11. Insect life, bird life, earthworm, etc.

We try to parallel this garden work by considering the questions relating to uncultivated areas; nature's method of planting and weeding; number of seeds germinating on a given area; seed distribution; temperature and life; meaning of early green spots, etc.

These problems do not come to the pupil as assigned lessons but they spring out of his from day-to-day experiences; and the answers to these questions are essential to the continuation of certain particular phases of thought and action. In the earlier or "rambling" stage of this out-of-door work the pupil was guided largely by his instinct of curiosity, when his curiosity was satisfied there remained no logical reason why he should give the object or phenomenon which attracted his attention, any further consideration. The pupil may begin work in the garden under much the same impulse, but by his act of planting he assumes certain duties which may lose their pleasureable elements—but which must be attended just the same in order that he may succeed in his original purpose—the repeated need of destroying weeds and loosening the soil may serve as an example.

It is comparatively easy to do a bit of work when results follow immediately, but it is quite a different matter to work patiently and conscientiously when results are remote. The development of this quality is one of the important functions of teaching. It seems to me that it is just at this stage where the frequently agitated question of discipline comes in—by the act of planting the pupil becomes responsible to a degree, for the fruitage, and nothing short of his best efforts to obtain adequate results should be allowed to pass; he has begun work with a definite purpose; nothing short of the accomplishment of the purpose shall satisfy him. This general science work is usually carried on under the head of Nature Study which has been a strong factor in recognizing the child's interest in nature and extending the range of his experience with nature; the weak point of the work has been in a general failure to provide means for accumulating and unifying these observations and experiences. Much time and energy is spent in observation, experimentation, and collecting data, but when the time comes for a more adequate working up of this data, for its broader interpretation we find that much of it has oozed away. While it may have broadened the interest and trained the senses it has not always given a type of mental poise and control which insures the pupils making best use of experience. We need to give more special attention to devising means for accumulating the more essential observations. There are a variety of ways in which the pupil's from-day-to-day experiences may be accumulated,—

1. Experiences relating to climatic conditions.
   (a) Character of the day—sunshine, clouds or rain.
   (b) Direction of wind during each state of conditions; (1) winds that bring clouds; (2) clearing winds.
   (c) Daily range of temperature,—winds and temperature.
   (d) Daily range of barometer.
   (e) Time of sunrise and sunset and position as to east and west.

(f) Noon position of the sun-degrees from the vertical at various seasons and influences on temperature.

(g) Records as to the conditions of life at various seasons and adaptations to climatic changes. Following this period of record taking comes a period of summarization and interpretation; a more definite study of climate and climatic controls.

These records have little significance if we collect our data from books and charts but they are full of meaning to the individual who has accumulated these records from nature. As the garden and these records afford opportunities for unifying experiences out of which we may formulate a series of problems so the natural features of the landscape may be made to serve a similar purpose. The surface of the earth of any region may be considered as consisting of a number of type topographic or rather physiographic features; these may be grouped under the headings of

1. Shores and beaches of varied types and their associated features.
2. Lakelets, lagoons, and marshes and their associated features.
3. Gullies, ravines, valleys and their associated features.
4. Hummocks, hills, and ridges and their associated features.
5. Levels, flats and their associated features.

Each one of these types may be considered a unit environment and as such a center for unifying the various phases of study pertaining to it.

Each region is largely controlled by a special set of physical conditions; a complete study of any one of these centers should lead to an intelligent appreciation of the contents of the area, their true relationship, and the factors which most influence the type of region. If the action of certain forces as running water, glaciers, winds, wave action, has moulded the contour of the earth's surface, and contour and structure modify the physical conditions of moisture, temperature, light, and wind, and these in turn influence life, then our study of the area should develop an intelligent appreciation of these interrelations. Our frequent failure to have pupils study a region as a region, to learn, to enjoy, appreciate, and read landscape and its life, before taking up the isolated studies of Physiography, Botany, and Zoology, reduces greatly their breadth of outlook and the effectiveness of teaching and student effort.

One of the prominent features of the Chicago region is the marsh;—Something of the attractiveness of this type of area is indicated by the way it is frequented by the physiographer, the botanist, the zoologist, flower pickers, hunters, and wandering boys.—In the study of this area the specialist is absorbed in his particular subjects; the non-specialist tries to take a more comprehensive view—he is there to study the marsh as a unit, and we may consider that he has formulated some such outline as follows to guide him in unifying his study:

1. Gaining a good impression of the general physiognomy and atmosphere of the marsh.

2. The conditions essential to the formation of a marsh, (a) Topographic conditions, (b) Structural conditions, (c) Climatic conditions.

3. The various ways in which marshes may originate, (a) Genesis of the marsh under consideration, (b) Changes which the marsh has undergone since its genesis.

4. Acquaintance with the content of plant life of the area, (a) Its zonal distribution and conditions controlling this distribution, (b) Its adaptations to the physical conditions of the area.

5. Acquaintance with the animal life of the area, (a) Its distribution within the area, (b) Its entrance into the area, (c) Life histories and adaptations.

6. The ultimate end of the marsh as a marsh, and how this end is brought about.

It is safe to assume that the elementary student gives little attention or thought to these problems. The things that appeal to him are the mud, the cat-tails, lily pads, tadpoles, frogs, and crayfish; how the marsh got there, from whence these things came and whither they are going does not trouble him. It is sufficient that they are there and he sets to work to get all the pleasure he can by discovery, observation, and collecting. It is our first duty to see to it that he gets a broad experience with these things.

The region as approached by the student gives little hint of the problems outlined above; these problems are to grow out of his swamp experience and study. If we are going to study the marsh and begin in the primary grade it will not be necessary to give any very detailed directions as a preparation for the trip; if we are going to study some special phase, and begin at the period of 10-12 years, then directions are essential. If we see to it that adequate provision is made for the care of collected materials we may rest assured that with but little field direction a very considerable amount of materials will be secured for the school room study. The interest and work of the future trips will be largely determined by the use made of this collected material; and out of this study should evolve definite problems and preparations for a succeeding trip. No preparation can equal these unsolved problems which the pupils carry with them from the recitation.

In addition to the regular discussion relating to the trip, and this material, part of the material may be used, (1) for accumulating certain records in writing, drawing, and color.

Ex. Showing in color or drawing the variety of plants growing in the region, this record includes all the elements involved in any drawing or painting lesson and has the additional value of acquainting pupils with the type and the names of plants growing in a marsh region.

Another type of this material may be placed in boxes, jars or acquaria for detailed observation and record. (a) Development of frog, snail, aquatic insect and salamander eggs. (b) Movement and respiration of aquatic form. (c) Food and feeding habit. These may for the time being be considered special studies; but the results add continually to our growing conception of the marsh.

Another method of work is in preserving the material itself and in selecting and arranging this material to bring out certain special phases of knowledge. (1) The preservation of the animal forms of the swamp area in order to see together the full range of aquatic forms; for identification and to be used later to develop the principles of systematic classification. (2) Collecting and arranging material to show the successive stages in development of frog, salamander, insect. (3) Collecting to illustrate food and feeding. (4) Meaning of color.

These collections should form the center of a school museum, a museum not of curios and miscellaneous materials, but a museum which represented the thoughtful and intelligent work of a body of students and teachers, not a collection of case-locked curios but materials to be used and developed in school study. This method of work makes it possible to bring under intelligent inspection a vast quantity of materials otherwise so separated by time and space as to remain meaningless. Each of these collections represent a separate study and each separate study unites to form the basis for a still more extensive study. Each study gives the pupil a definite problem, gives him an opportunity to be active in his work, develops skill, and fixes in a never-to-be-forgotten way a group of essential facts. These various types of ways of dealing with field materials is legitimate elementary work: Developing skill in reading, writing, painting, observation, experiment, all of which represents types of work thought of as belonging to elementary school work. We give the pupils all of this but the getting is not made an end; these things represent means. Here is a definite work to be done and the essential skill is acquired in the doing.

As these things accumulate, paintings, charts, collections, they exert a mighty influence upon the work of the student; they give him standards, he becomes eager to do better work, his purposes become more clearly defined, he becomes alert and alive to the things around him. The work becomes more and more the product of his own initiative and less of an assigned task. The thought horizon of the pupil broadens and he gradually acquires the power of more comprehensive generalization. Minot has made the statement that "great new thoughts are generated more by the accumulation of observation than by deep meditation; a generalization is a mountain of experience." This elementary field work should stand for this accumulation of observations, this mountain of experience, for the acquirement of skill, and for the development of the intellectual qualities of alertness, thoughtfulness, patience, definiteness of purpose and power of inference and generalization.

Through this elementary field work the pupil has had experiences with marsh, hill, valley, and prairie, he knows something of the contour of the earth's surface, he has seen something of the work of running water, gravity, waves, and winds—to him topography is something which may be read and explained. He has collected data which gives him hints as to climate control and the influence of climate on life. He has had some chance to feel his own worth.

If our elementary work can succeed in developing in pupils (1) A feeling of pleasure in nature, (2) An intelligent attitude towards nature, (3) can succeed in having the pupils detect the problems relating to their out-of-door environment, and (4) have them gain some power in knowing how to set to work to solve these problems it will have accomplished a great work. The value of this work must be tested by its influence on the individual and not upon the basis of systematic knowledge; knowledge may be the test when the student has had ample time to more fully systematize and complete these various phases of study but at this elementary stage the test must be based on working efficiency. Having acquired working efficiency, having, as it were, learned his trade of how to study, we may then hold him responsible for the accomplishment of some worthy work. It is the function and duty of the teacher in this elementary work to formulate an ideal as to the personal qualities which a student should possess; he should give thoughtful attention to the conditions essential to the development of these qualities, and then set to work with all the resources of knowledge to the accomplishment of this purpose. It is in this way only that we can hope to develop a science of teaching. I see no study which has the possibilities of contributing so much to this purpose as field work.

DISCUSSION OF ELEMENTARY FIELD WORK: AIMS AND METHODS.

PROFESSOR L. H. BAILEY, CORNELL UNIVERSITY.

I agree most heartily with the propositions that have been put forward by Professor Myers. I am particularly pleased with his attitude towards the field work and the excursion. The whole tendency of education is to put the school and the child into actual sympathetic relation with his environment. Biological work should normally and naturally be outdoor work. The indoor laboratory should be a supplement to the outdoor work, but it has been the fault of much of our teaching that the outdoor work has been dominated by the laboratory. It is the laboratory and not the field work that is the adjunct. It is very difficult to manage excursion work without having it become mere recreation or a rambling outing. It is not necessary to tell the pupil what is to be seen when he goes abroad, but usually he should go with a definite purpose in mind. At one time he may go for the specific purpose of seeing the edge of a swamp, a hill, or a particular tree or a particular bird, or a definite part of a brook or pond. He may go to study fish or turtles. The object of the excursion should be clearly outlined before the children go abroad and their work then becomes relevant and concrete. It is well enough, of course, to take the whole school on an outing two or three times a year. This, however, must be looked upon as a picnic rather than as definite educational work. When it is the

purpose to make the excursion of educational value it should comprise as few pupils as possible. It is difficult to handle as few as twenty pupils in many kinds of excursion work. From six to ten is a better number. This, of course, precludes the possibility of doing any definite excursion work in most rural schools of one teacher, since the remainder of the pupils would then be left uncared for.

I think that there is danger in making an excursion as formal and as perfunctory as much of the laboratory work has been. We are in danger of forgetting that the spiritual quality of school work may be the thing most to be desired. The biological work is not expected to supply the formal "drill," but rather to provide the quality and vivacity of school work. It develops the native powers of the individual and arouses and stimulates, and sets the pupil definitely at work with a personal problem.

It seems to me it is time that we should consider the industries and the affairs of the community as coming within the realm of the school enterprise. Study the creamery of the town and various other industries. The affairs of men are immensely important to the child and certain of these subjects can be made teachable by being unified, systematized and developed as to standards.

Work in the field may be carried on along several different lines, as follows:

I. The Weather.

First year—Very general weather observations. Try to eliminate the habit of complaining at the weather.

Second year—Study of clouds, with observations on a sun-dial made by the manual training department.

Third year—Study of the wind.

Fourth year—Study of temperature and observations on the thermometer.

Fifth year—The barometer, weather maps, signals and forecasts.

II. Scenery—Survey of country. Strive for an understanding of topographic forms and in the

Third year begin a regular survey of a brook, a swamp, or a hill in your region.

Fourth year—Continue the survey and take measurements.

Fifth year—Describe and plat the same area.

III. Animal Population of the Region. The first year teach the names of the most familiar animals and plants. The second year commence a particular study of special groups of animals, beginning with birds and concluding in the fifth year with insects.

IV. Similar Observations on Plants.

It is, of course, quite impossible always to find the objects and the phenomena in the open field that one desires for the best work. Every good school, therefore, should have a new type of biological laboratory. This

laboratory is the school-garden. The school-garden should be introduced not for the purpose primarily of teaching gardening, but in order that the pupil may have a natural realm that is under more or less control. The time is coming soon when the school garden will take the place of much of the indoor laboratory work because it is more normal and natural. and is more likely to develop indigenous and native powers. It teaches handicraft in cleaning and caring for tools, laying out of walks, making flower beds, etc., and is the place to learn how plants grow. It is a scene of life.

AIMS AND METHODS OF PHYSIOGRAPHIC FIELD WORK IN SECONDARY SCHOOLS.

PROFESSOR M. S. W. JEFFERSON, STATE NORMAL COLLEGE.

Physiography is the old Physical Geography plus field work. It deals in good part with landscapes and processes, which may be studied through: 1 Pictures. 2 Maps. 3 Books. 4 The objects themselves.

Hitherto only the first three ways have been much attempted, but the burden of proof should rest with any one who ventures to justify such an arrangement or that we ought to study symbols rather than things.

Why not study the forms themselves? We do not enjoy a picture or a song or a dinner by reading about it, but by seeing it, hearing it, or eating it. If out of reach we may take some pleasure in the description, but not with any thought that we are having something as good as the thing itself. And even what little comfort there is in this second-hand treatment comes from previous dinners, songs, and pictures that we have actually enjoyed. Let us then see the near processes and landscapes and try to understand as much as we can of them. So we may hope for a better understanding of distant scenes and processes. As in every study, we are trying to master symbols and we cannot do this by omitting the things to which the symbols refer.

METHODS.

The teacher should catalogue the physiographic features of his neighborhood and arrange them in the order of importance from their generality of application in the science. Do not plan a lot of excursions. Ask for time for one—but be sure to make that a good one. Limit the number to go and plan the lesson with great care. By questions the class is gotten to look at the details concerned and to find reasons for conditions which should always be fairly easy to find in the first lesson. For instance, go to a brook. Ask, where are the biggest pebbles? Where is the smallest stuff? Where is the water going fastest? Why are the big pebbles over there? Perhaps no one can answer at first. Put some fine material in swift water and then ask again. Then the class may be asked to find other illustrations.

Probably the field trips should come first. But you plan it so and perhaps it rains, so it may be necessary to take the book lesson first.

It is impossible to apportion the number of field and class exercises, but doubtless one in three or four would be the most. But the most important consideration of all is that the teacher herself must be in sympathy with field work and shall be able to *see*. See Journal of Geography, February, 1905.

DISCUSSION OF AIMS AND METHODS OF PHYSIOGRAPHIC FIELD WORK IN SECONDARY SCHOOLS.

PROFESSOR R. D. CALKINS, CENTRAL NORMAL SCHOOL.

While nearly everyone who is entitled to express an opinion recognizes that out of door work is the one thing that is chiefly lacking in the geographic instruction of our state, there are so few who are attempting it. At the present stage of development if the few advocates spend their time at such meetings in quarreling over the methods of field work when the vital question is not so much the method by which the work is done as that field work shall be done or attempted—more harm will be done than good. Need of the hour is that friends of modern geography shall unite in spite of minor differences and create a public opinion which shall sweep the state and compel certain much needed improvement in geography teaching. And so I say Amen to all Professor Jefferson has said.

He has shown convincingly and without need of further discussion why field work is necessary—and yet I feel that there are many superintendents who feel that all this uproar about laboratory and field work is all nonsense, else why do they allow the same old methods to continue in their schools?

Granted that they are anxious to do the work but are hindered by obstacles:—

(1) Material equipment, etc., easily supplied.

(2) Arrangement of classes, so as to give time for field work, only requires a little gumption on the part of the superintendent.

(3) Lack of teachers who can see about them the forms and processes which make clear the book statements concerning them chief difficulty.

Physiography teaching has not yet evolved to the point where a discussion of the aims and methods of field work is of the greatest possible value; when there are not—how many?—shall I say fifty, forty, thirty teachers in the state who are capable of doing field work!

Something ought to be done to create a demand for science teachers who can teach physiography. The work in normals and colleges is largely elective, so superintendents must *demand* that science teachers shall elect physiography along with botany and zoology, or physics and chemistry.

But leaving all this and taking up the question of methods of field work, can there, under the varying conditions of environment and experience of

the teachers, be any general or universal method of field work? Must not a discussion of methods resolve itself into a testimony meeting where each merely gives the results of his own experience? Such a comparison would be valuable to those who are trying to get some aid or suggestions for conducting such work. Does it not all rest with the teacher and his preparation?

The only basis which I can see for a discussion that would yield any profitable returns, is the question of whether the field work should precede or follow the class exercises, and even here no one would ever insist that either the one or the other order could or should always be followed. But whichever order be used it must necessarily follow that the method employed will differ radically from that used if the opposite order be observed. That the field trip should precede were it not for the uncertainty of the weather, etc., I do not believe to be always the case.

Were the class composed of third or fourth grade pupils still in the observational state of their mental development, there would be little question as to the order. But with tenth or eleventh grade pupils who have advanced to the reasoning stage and that with little if any training in observation, it may well be that the class may be led deductively to certain conclusions before going into the field, with the result of increased interest and attention in the field work which follows.

This statement will vary as to its truth, not only with the pupils but with the topic under consideration. As illustrations let us take

1. The case of the origin of gullies and their development into valleys with permanent streams. By appeal to the student's general experience and by deductive reasoning under careful questioning the class may be given a preparation for the field trip which is to follow that will enable them to do some independent observing of their own which then may be supplemented by the teacher's pointing out what he has not seen. There are often many reasons why the field trip should follow the class exercise or recitation.

2. But in the study of the glacial phenomena it is essential that field study of the glacial drift, for example, should precede the text-book.

It all resolves itself into this: That order or method is best which in the judgment of the teacher using it accomplishes most satisfactorily the results aimed at.

AIMS AND METHODS OF BOTANICAL FIELD WORK IN SECONDARY SCHOOLS.

DR. H. C. COWLES, UNIVERSITY OF CHICAGO.

One of the great aims in botanical field work should be to keep alive the love of nature. With most children the love of nature is choked out at school because so many other things are crammed down, and at home it is clubbed out because the child brings in mud. The whole education of the child is away from nature. All *science* teaching is more or less artificial. It is necessarily so and even the need of microscopic work in the high schools must be admitted. All people may be divided into two classes: those who travel by day and those who travel at night. To one who has eyes to see the things of nature every journey will be full of interest. Even a trip through Arizona in midsummer may be one of greatest interest and pleasure.

The first Botany, in the days of Gray, brought a certain nearness to nature, but we felt it to be rather purposeless and unscientific. Then came laboratory morphology which was scientific but lost the nearness to nature. Now ecology combines both.

But as desirable as field work is, it should not be attempted unless it can be orderly and definite. To be a success it must be better organized than laboratory work, just as laboratory work must be better organized than recitation work. For instance one trip may be to study the habit of growth and the forms of mosses, another the lichens, etc.

The best type of field work is a study of adaptations combined with a study of structure and function. If roots are to be studied—dig up plants to see the few roots of water plants, and the extremely large roots of dry soil plants, then take them to the laboratory for microscopical study. The form and size of leaves may be studied in their relation to light; then have experiments on heliotropism, transpiration, and starch making. Make the starch test on leaves that grow in the shade and those that grow in the sunlight.

Herbaria may be turned along ecological lines. Instead of being grouped according to families, they may be grouped as peat bog plants, sand dune plants, rock plants, leaf types which are mesophytic, leaf types which are xerophytic, etc.

The study of plant associations is the most difficult of all field work, but even here something may be done and the students' accuracy may be cultivated by making maps. A study of the changes going on may be made by letting students of one class make a map of a certain region and the next class make a map of the same area.

One of the greatest difficulties in carrying on field work is that of large classes, but an enthusiastic teacher will find ways of overcoming even this difficulty. Time in which to do the work is often hard to arrange. The time ought to come when certain half days will be set apart in the

school schedule for field work. Of all the difficulties suggested that of no good place to take the classes is the most inane nonsense. A more unpromising place in which to do field work could hardly be thought of than the down town districts of Chicago, yet even here vacant lots furnish abundant material for study, and transportation makes other regions easily available. The greatest difficulty of all is bad teachers. Teachers may be classified into those who are teaching for the money there is in it and incurable teachers. By incurable teachers is meant that class of teachers who have such a love for the work that they would rather teach than do anything else. They are the only class who should teach at all and certainly are the only teachers who should attempt field work.

DISCUSSION OF AIMS AND METHODS OF BOTANICAL FIELD WORK IN SECONDARY SCHOOLS.

E. L. MOSELEY, SANDUSKY HIGH SCHOOL.

I am told that most high school botany teachers do not make a practice of taking their pupils to the fields and woods. The difficulties to be encountered in such an undertaking appear to be overestimated. The advantages are well worth the effort. Not knowing what points would be brought out in Professor Cowles' paper, I can perhaps do no better than to tell of the methods employed at Sandusky. No doubt much improvement could be made there, and these methods might be wholly unsuited to some schools. In describing our excursions I cannot adhere strictly to the subject assigned me, for while many of our excursions are mainly for botanical study, observations pertaining to zoology and physiography almost always form a part and in many of the excursions an important part of the work.

TIMES.

Our excursions are at various times. On a fine day a class is sometimes taken out at its regular recitation period for a walk through the park or along a street bordered with spacious yards where a variety of trees may be found and in May wood warblers of several kinds and other birds may be seen. The class is back at the school house at the end of the period unless it is followed by recess or noon intermission. In the latter case it is dismissed at the same time as the school without returning. These peripatetic lessons are not announced beforehand and are not so frequent as to be expected, but come as a pleasant surprise. They might profitably be given more frequently at Sandusky and at many other schools where surroundings are suitable.

In the spring, excursions, previously announced are given after school and each pupil in botany or zoology has an opportunity to go about once in

two weeks, sometimes oftener. Some of them are open to the whole biology class, about sixty; those intended especially to see birds are often limited to one of the two sections, but if a pupil has work to prevent him from accompanying his section, no objection is made to his going with the other section. The average attendance of these after-school excursions is less than half of the class, or section, at one time; but most of the pupils go once or twice in the course of the spring and a few go nearly every time.

A combination of the preceding times may be utilized if the school program is so arranged that the science class under consideration comes the last period of the day.

From these after-school excursions we usually return for supper, but in the long days of late spring we sometimes go by boat and take a lunch along.

The excursions the pupils look forward to with keenest anticipation and remember in after years, are those given Saturdays or holidays. These are announced beforehand, often more than a week before. Sometimes they are for the forenoon only or the afternoon, usually for the day. In some instances, if the distance is great, they extend into the evening. In any case the approximate time of return is announced before the day of the excursion so that the pupils may prepare their lunch and will know whether if they go they will be back in time to meet other engagements. It rarely happens that all but one or two in a class of twenty-five go. In large classes or if the excursion is for the whole high school the number to go is not often more than two-thirds of the whole. It may average two-fifths. Very few biology students miss all of the Saturday excursions. Some go on nearly every one.

TRANSPORTATION.

On the excursions after school we usually go by trolley car, some of the class using their bicycles instead. The distance is between two and four miles. Frequently some who go by car prefer to walk home. Sometimes we walk from the school house to the outskirts of the city. Formerly when horses available for such purposes were not so scarce we would drive several miles after school. Once or twice in the spring we cross the bay in a launch or sail boat.

On the Saturday excursions all of these means have been employed and sometimes combinations of them. The objective points then are usually between five and seventeen miles away, occasionally farther. The electric lines are used most frequently, rarely the steam railroads, often steamboats or naphtha launches. It is a question whether the excursions on the water in fine weather or the drives are enjoyed the most. Fine excursions have sometimes involved a ride of twelve to twenty miles by car and then a drive along a river valley.

EXPENSES.

Reduced rates are usually secured for transportation on the Saturday excursions, lower in many instances than most people ever secure for the

same trips. Boats are often chartered. Sometimes we can use them without interfering with their regular trips. The average expense for each pupil, whether the excursion is on water or on land, is probably not more than thirty cents for the round trip. Frequently it is but little more than one cent a mile by car and less than one cent a mile by boat. Once on a thirty-five mile drive we had about a dozen carriages without hiring any. At another time we were met at the electric car twelve miles from Sandusky by pupils who lived within six miles of the spot and other friends in such number that by hiring one team we were able to take a very enjoyable and profitable drive although there were about sixty of us.

PREPARATION.

Before going on a long excursion I oftentimes tell the class in advance something about the region to be visited or give some instruction concerning subjects of which the region affords fine illustrations. Sometimes I have them copy a list of the things to be noticed,—trees with which they are not already familiar, shrubs or herbs they have heard of but not yet seen growing, birds and mammals they ought to see and hear, geological formations.

A brief list of things to take, depending on season, place, time of return, and main objects of excursion, is useful, e. g., old clothes, rubbers, warm wraps for the return, vasculum or other large box and small boxes for delicate specimens, a field or opera glass and sharp eyes. A small map showing all the roads has been given to each pupil on some of the excursions and they are told to keep them and take them on other excursions, but they usually forget to do so. It is well to have at least one topographic map along, if any exists.

INSTRUCTION.

While on the excursion the teacher should not expect the pupils to be listening to him continually. To several five minute talks at suitable times and places he may reasonably insist on all listening. Besides these he may point out numerous things along the way in such a manner that the majority may either hear him or learn from those that did hear what the things are. The pupils, if not too old, discover plenty of interesting things which they are glad to bring to the notice of the teacher and glad to learn something about either by investigation or from oral instruction. After the excursion, part of the class time may be profitably spent in questioning the pupils about what they saw, correcting false impressions and adding points of interest.

RECREATION.

On the long excursions it is unreasonable to expect that the pupils will devote their whole time to the subjects they are studying. Lunch at some picturesque spot accessible to a good spring or well should be followed by time for rest, during which those who are never tired can play ball or hunt

for snakes or amuse themselves in other ways. Many of the girls will endure the walk better if they have a good rest at this time.

CONDUCT OF PUPILS.

Some have supposed there would be much difficulty in maintaining any sort of discipline among pupils while on an excursion. No doubt some teachers who have made only one or two attempts at conducting excursions have found the responsibility a considerable nervous strain. Pupils, too, who have never been on a school excursion before and who doubt if they will be able to go again sometimes do foolish things. On the other hand excursions afford a fine opportunity for the teacher to instill in the minds of the pupils fundamental notions of the data of ethics. Many of them have failed to learn at home that the test of conduct is whether on the whole it tends both immediately and remotely to the good of the doer and others concerned. Many of them have come to regard parental displeasure the only thing to avoid. It is not hard to teach the pupil that when on an excursion he is expected to have a good time, but he must not destroy property nor do anything else likely to cause serious annoyance either to schoolmates or strangers.

The large excursions I have found most difficult to manage are those in which we make use of carriages. This is on account of the difficulty of keeping the party together. If a pupil drives a horse which he has himself furnished, he is likely to feel somewhat independent. Sometimes it is difficult to prevent racing. The carriage in the lead may take the wrong road and others follow. I have found that much trouble could be saved by insisting that none of the party should drive ahead of the carriage in which I was at the time riding. If the party is small enough to be accommodated by a single band wagon or two or three hired vehicles there is usually no trouble.

Conversation is usually unrestrained except that I discourage gossip and long stories and try to keep the attention up to lunch time and for a portion of the afternoon on the things they are observing. Some pupils find it difficult to keep still during even a short talk by the teacher or to refrain from annoying others at such times. If they prove troublesome on more than one excursion they can before another excursion be denied the privilege of going. I have rarely found it necessary to resort to this expedient.

On many of the excursions there has been nothing to worry about, unless it was the tendency of some of the party when tired to sit or lie on the bare ground and remain there till they caught cold.

It is well for the pupils to understand beforehand that if they go on the excursion they are not to absent themselves long from the rest of the party without getting permission to do so.

An imaginary objection to field work on the part of those who have never undertaken it is that the freedom of the children on an excursion will lead to their taking too much liberty in the school room. Experience does not accord with this apprehension.

Some have observed that while on an excursion the interest of a pupil is likely to be centered in some person instead of the things they are expected to see. This is seldom the case with pupils under sixteen and after that it should not be regarded so objectionable as to prevent the excursion. In one class where I thought certain ones would go after school only because of their interest in other members of the same class, I went with the boys certain afternoons and the girls other afternoons, but this has seldom been found necessary.

BENEFITS.

Without discussing the subjects to be studied on these excursions I will mention a few benefits to be derived from them that might be overlooked—healthful recreation, an opportunity to see and understand many things mentioned in literature as well as in science and especially a love of nature that adds much to the enjoyment of life.

The following sentence is in Felix Oswald's Physical Education: "No domestic events of our later years can efface the impression of the woodland rambles, butterfly hunts, and huckleberry expeditions of our boyhood; the recollection of first outdoor adventures endure like the mountains and rivers of a promised land whose cities have vanished forever."

Three years ago I gave a paper here on "Original Work for the High School Science Teacher." The conclusion of that paper I will give also as the conclusion of this.

The teacher of natural science who would imbue his pupils with the spirit of investigation should not be content to invoke their assistance in prosecuting his own researches. He should inspire them with a love of nature. To do this he must take them into the country. Some teachers whose early life was spent in the country or in a village fail to realize when they begin to teach in a city how meagre is their pupils' experience with the subjects they are trying to teach them. Until I take them into the country some of my pupils have never seen a sheep, a peacock, or a snake. Some imagine that strawberries grow on tall bushes. Many of them have scarcely, if ever, in their lives seen a hill or a river, save sometime, perhaps, from a car window. The expressions, "up stream" and "down stream", are meaningless to them. They listen attentively in the class-room to a description of the characteristics of a lake beach, but when shown a mole hill they are not sure that it is not a lake beach. Nor have they more knowledge of a beech tree. Not one in ten ever saw beech trees until taken to them by their teacher. The same is true of the hemlock, the witch hazel and many other highly interesting plants. Other trees such as the buttonwood and ash they have seen but never had an opportunity to learn to know them. They do not recognize the note of the meadowlark or the kildeer, or know the difference between a chipping sparrow, and a chipmunk.

The burrow of the woodchuck, the chimney of the crayfish, the ants caring for their pupae and for the plant lice, the protective resemblance to their surroundings of the rabbit, of the grasshopper and the whippoorwill,

the protracted flight of the swallow and the quick movements of the kingbird, the singing of the bobolink and brown thrasher;—these things cannot be brought to the school room. Yet these, and not dried specimens, represent life. To fail to give them any knowledge of these things is to deprive them of a source of enjoyment whose pursuit would do more to enrich their lives than any luxuries that money can buy.

MATHEMATICAL CONFERENCE

NON-EUCLIDEAN GEOMETRY.

LOUIS C. KARPINSKI, UNIVERSITY OF MICHIGAN.

Great discoveries have often been made by scientists working in different places and entirely independent of each other. Sometimes the circumstances can be ascribed only to chance, but often times it is the result of the preparation that has been made in the previous years leading to that truth. Four men, each quite entirely independent of the other three, worked out about the same time a system of non-euclidean geometry, or, at least, had the fundamental ideas necessary for the construction of such a geometry. The great Gauss and one Schweikart, Professor of Law in Charkof, recognized some ten years before Lobatschefskij's work was published the possibility of a consistent geomtry in which the sum of the angles of a triangle should be less than two right angles. Neither Gauss nor Schweikart published anything on this subject although Taurinus, a nephew of Schweikart, published in 1826 the formulæ for spherical triangles in which the sides are given pure imaginary values and he noted that these formulæ state the relations existing among th sides and the angles of a triangle in which the sum of the angles is less than two right angles. Lobatschefskij, Professor of Mathematics in the University of Kasan, and Johann Bolyai, Lieutenant in the Austrian army, conceived and developed almost simultaneously this geometry. Lobatschefskij's first works on the subject were published in 1829 and 1830, and Bolyai's one work was given to the public in 1832.

In our present discussion we will follow largely Lobatschefskij. We will give the proofs of a few of the fundamental propositions and we will state a number of the results which are of especial interest to teachers of elementary geometry.

Of the postulates and axioms of Euclid six stand out as essentially geometrical.

1. That a straight line may be drawn from any one point to any other.
2. That a straight line may be prolonged to any length.
3. That a circle may be described about any center with any radius.
4. That all right angles are equal.
5. That two straight lines do not enclose a space.

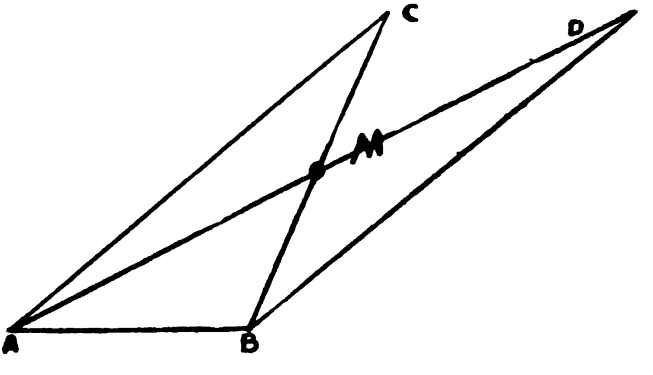
6. If a straight line meet two other straight lines so as to make the two interior angles on the same side of it together less than two right angles, these two straight lines being continually produced shall at length meet on that side of the straight line on which the sum of the angles is less than two right.

This is usually given as Axiom 12, but Heiberg and other authorities agree that it is a postulate in the original. It is essentially different than the others. Euclid could have worded it as follows: "That through one point only one parallel can be drawn to a given line," or, "That through any three points a circle can be drawn," or "That the sum of the angles of a triangle equal two right angles." But from the form of the wording and the fact that Euclid does not use this postulate for the first 26 propositions, Book I, we conclude that Euclid recognized the inherent difficulties of any theory of parallels. This stumbling block to progress toward any rigid grounding of the science of geometry was removed only after some 2,000 years of speculation, and now, indeed, has become almost the headstone of the corner.

It is of some interest to note that as early as the fifth century Proklus criticized Euclid's postulate and wished to substitute for this that two lines that are everywhere equi-distant are parallel. Attempts to prove the postulate were numerous in the twelfth and thirteenth centuries among the Arabs, and in the seventeenth and eighteenth centuries in England, France, and Italy. Saccheri, an Italian, 1667-1733, and Lambert, a German Swiss, 1728-1777, made the greatest progress in this work, developing to a large extent the work completed by Lobatschefskij and Bolyai

We will demonstrate two fundamental propositions.

1. That the sum of the angles in any triangle equals or is less than two right, the straight line being assumed infinite in length.

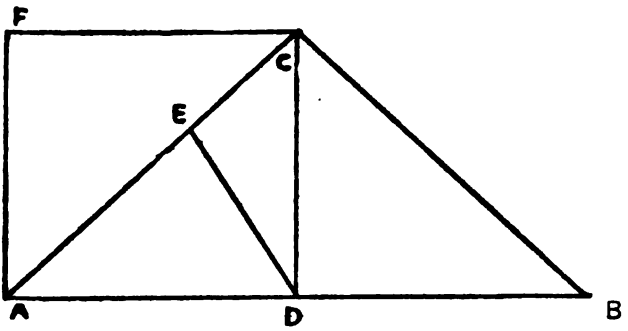


2. That if in any triangle the sum of the angles equals two right angles then in every triangle the same holds true.

Let ABC be any triangle and A the smallest angle. Through M, midpoint of BC, draw AMD, making MD equal AM. Connect D and B.

Triangle MBD equals triangle MCA. Sum of the angles of triangle ABD is same as of ABC and angles DAB and ADB together equal angle CAB. Take the smaller of angles DAB and ADB and repeat operation—suppose it DAB. Then DAB is less than ½ CAB. Next angle D^1AB is less than ¼ CAB and so on. Assume the sum of the angles of the triangle equal 2 Rt. + α. We can continue operation until sum of the smaller angles is less than α since it is less than $\frac{1}{2^n}$ CAB, and therefore the sum of the angles is less than 2 R + α.

∴ Sum of the angles of any triangle is less than two right angles or equal to two right.



Suppose sum of angles of A C B equal two right. Then any triangle cut off as A D C also contains two right. Suppose A D C has angle sum equal 2 R — x, then D C B equals 2 R — y and 2 R — (x + y) = sum of angles of A B C equals two right.

∴ x + y = o, and x = y = o as both x and y are positive. Similarly A D E. Also the right triangle A D C has angle sum two right and rectangle A D C F can be built. Any right triangle can be included in a larger rectangle built up from such small ones.

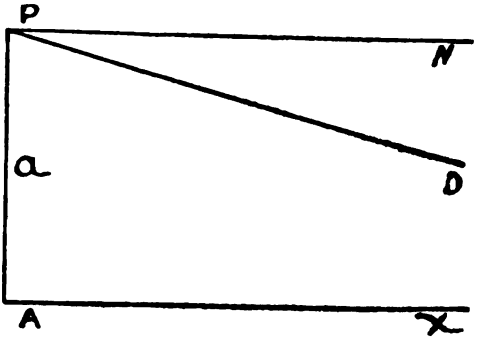
∴ Sum of angles of any triangle equals or is less than two right angles if it is so in any one triangle.

A proposition which follows quite simply is that two triangles in which the sum is less than two right are congruent of three angles of the one are respectively equal to the three angles of the other. Also that two triangles whose angle sums are equal are equivalent in area.

Given any line of length a and A X perpendicular to it. Then it is certain that through P one line can be drawn which does not meet A X, viz., the perpendicular P N to P A at P since if this met P X we would have a triangle whose angle sum is greater than two right. In passing from P A to P N by rotation we pass from lines that cut A X to lines that do not cut and suppose P D the first line which does not cut A X. Then in our new terminology we will understand P D to be the parallel to A X. It is evident that there is another parallel similarly situated on the other side making

angle A P D' equal angle A P D. This means that the line has two points at infinity (in different directions). The angle A P D is called the angle of parallelism for the distance a and is designated by π (a). In the usual sense of parallels we see that there are an infinite number of parallels to the line A X on the side X, viz., all the lines between P D and P N.

If we assume that the sum of the angles of a triangle equals two right angles we can show that then only one parallel is possible. It follows that in our new geometry the sum of the angles of a triangle is less than two right angles. It is easy to prove also that if two lines which meet a third so as to make the sum of the interior angle equal two right are parallel then the sum of the angles of a triangle equals two right. It is evident, then,



that Euclid's assumption is equivalent to the assumption that the sum of the angles of a triangle equal two right, or to that two such lines as given above are parallel.

Somepropositions evident in Euclidean geometry must be demonstrated in the new geometry. If P D is given parallel to A X it is necessary to prove that A X is parallel to P D. Also that two lines parallel to a third are parallel to each other.

The angle of parallelism is dependent upon the distance a, and grows smaller as a grows larger, varying from $\frac{1}{2}\pi$ to π^2.

There are no similar triangles and propositions based upon proportion must be restated.

The sum of the squares algebraically of two sides of a right triangle is less than the square upon the hypotenuse.

There are no squares and rectangles in a geometric sense—else there were triangles whose angle sum would be two right.

The perpendiculars erected at the middle points of the sides of a triangle may meet in a point, otherwise the three are parallel among themselves or all three are non-intersecting lines.

A circle with infinite radius is not a straight line in this geometry but is a boundary curve. Any two parallels to an axis of this boundary curve are equally inclined to their chord of contact. A boundary surface is obtained

by revolving such a curve upon one of its axis and on this surface Euclidean geometry holds.

The trigonometric formulæ must be largely modified. We have in a right triangle, c being the hypotenuse,

$$\sin \pi (c) = \sin \pi (a) \sin \pi (b).$$
$$\cos \pi (a) = \cos B \cos \pi (c).$$
$$\sin B = \cos A \sin \pi (a).$$

in which π (a), etc., are the angles of parallelism as before defined, and A, B, C the angles opposite sides a, b, and c.

In the general triangle we have ch a = ch b chc — sh b shc cos A wherein ch and sh stand for the hyperbolic cosine and sine. This formula corresponds exactly to the change from x to ix for the side of a spherical triangle in the ordinary form.

Cos a = cos b cos c + sin b sin c cos A, in which cos x and sin x are defined by

$$\frac{e^{ix} + e^{-ix}}{2} \text{ and } \frac{e^{ix} - e^{-ix}}{2i}$$

Any right triangle and any quadritatual having three right angles can be constructed with compass and ruler when two other elements are given. These constructions were touched upon by Bolyai and further developed by M. Gérard and M. Barbarin. The formulæ for the areas of given curved surfaces and volumes of solids have been derived.

In this geometry we assumed the straight line infinite in length. By which the sum of the angles of a triangle is greater than two right angles. An illustration of this is the geometry on a sphere.

We can construct surface which plays the same rôle with respect to the Lobatschefskijan geometry as the sphere does above, viz., the surface generated bythe tractrix revolving about an axis. This is a surface of constant negative curvature and all the constructions of the new geometry are possible upon it.

Certain propositions of this geometry can be well interpreted by figures on an imaginary sphere, *e. g.*, the area of a triangle on a real sphere equals $r^2 (A + B + C - \pi)$ or is proportional to the excess of the sum of the angles over 180° and making $r = r\sqrt{-1}$ this becomes

$$r^2 (\pi - (A + B + C)$$

which states that the area of a triangle is proportional to the deficiency of the sum of the angles from 180°.

There is an immense field of literature on the subject, largely in German and French. In English there are, among others, the following:

Professor H. P. Manning's Non-Euclidean Geometry.

Bolyai's Non-Euclidean Geometry and Lobachevoski's Non-Euclidean Geometry, both translated by Professor S. B. Halsted.

In German especially good, are the works Urkunden zur Geschichte der Nichtenklidische Geometric by Engel and Staeckel.

CERTAIN ASPECTS OF THE PRESENT TEACHING OF SECONDARY MATHEMATICS.

C. I. PALMER, ARMOUR INSTITUTE OF TECHNOLOGY.

Someone has remarked: "It is generally conceded that mathematics is one of the best taught subjects." Is this true? If so, what are we to say of the other subjects? It is not the purpose of this paper to answer these questions, but to set forth some few ideas and observations, and more existing facts regarding the present teaching of mathematics. In doing this I trust I shall be pardoned for speaking in some detail of the work at Armour Institute of Technology.

Much, very much, indeed, has been written and said in the past tew years, concerning laboratory methods in teaching mathematics. How we should use this experiment or that one, or make use of some complicated piece of apparatus in the mathematics class room. Many have theorized upon what should be done, but have never done anything. Their ideas may be good, but are of small value to the teacher. Others have written of exactly what they have done, and how they did it. From such a leader the teacher can get something.

Huxley has said that, "Mathematics is that study which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation." Some still hold to these ideas, and teach accordingly. But most of us, in this section of the country at least, see much in a close correlation between the different branches of mathematics, and the subjects of physics and mechanics.

The translation of physical and other facts into mathematical terms is one of the most important duties of the teacher of mathematics. The laboratory methods make this possible to a great degree.

It also makes possible and gives many opportunities for the use of mathematics, and gives to the thoughtful student an insight into its further uses. He sees that mathematics is a tool, and a powerful one, which gives the possessor advantages according to the fullness of his possession and ability to use.

Be not carried away with the beauty of the idea. Teachers have made this mistake too often. We are too apt to give out work in a sugar-coated form. Much of the experimental work is of this nature; the pupil is amused and entertained by the instruments and devices used. He does not get from the experiment what we see in it, and expect him to get from it. It amounts to about as much as does the measuring of saw-dust and sorting of tooth-picks when guided by an inexperienced and thoughtless teacher of the lower grades. As a bright boy in algebra, who was disgusted with his knowledge of arithmetic said, "When I was in the seventh grade we spent most of our time in handling blocks and bundles of tooth-picks." The point I wish to make is not that the laboratory methods

should be done away with, but that, perhaps, less should be attempted, and more careful thought given to what we do. Especially let us not lose sight of our algebra or arithmetic or geometry, or whatever we really have in hand.

What shall be the test of an experiment? Try this, if a problem involves a technical knowledge of another subject, and this knowledge cannot be given without detracting from the subject being taught, then this problem and the mathematics of it belongs to the other subject.

The pendulum is vibrating farther in some schools, and communities, than in others, but this is always true. Text-books have been discarded and adopted. First this method is all wrong, and then suddenly is accepted. Perhaps I can best show the present state of affairs by speaking of the conditions in the Armour Scientific Academy. Changes have been made, and are now being made—the pendulum is vibrating.

In the first year's work, which is that of the first year in the high schools, changes have come. Some two years ago we endeavored to do some geometrical construction work in the last term of the first year, besides covering the subject of algebra through quadratics, ratio, proportion, variation, progressions, and logarithms. Last year the geometrical construction and all the algebra past quadratics, except ratio and proportion, were left out of the course, and this year it is very doubtful if we do anything with ratio and proportions.

There are at least three reasons why these changes have been made. First, since our chief aim in the academy is to prepare students for the Institute of Technology, we are especially anxious that the preparation shall be thorough. In one year's time we have found that we could not do more than the necessary work through quadratics and master it for the algebra part of the year's work. Secondly, since each year and even each term we are receiving pupils from other schools, it causes more or less trouble in adjusting them if we are doing work very much different from other schools. This is the chief reason why we do not now touch logarithms until we are teaching trigonometry. When the students we had trained understood logarithms, and the subject had to be presented to nearly all others, the classes became somewhat demoralized, and it was easily seen that we were not working to the best advantage. For we argued that if we had to teach the subject twice when taught first in algebra, and only once, if taught first in trigonometry, it was obvious that time would be saved if the subject was presented first in the latter subject. Then, too, from the standpoint of teaching a thing when it is necessary to know it because needed for use, the decision was a sound one.

The third reason, and one in which my observation has not been as extensive as I wish it had, is the poor preparation in arithmetic of students on entering the Academy. My own observation and experience, and that of others, leads me to believe that the pupils, especially from the Chicago schools, are less well prepared in arithmetic than formerly. This year, for instance, out of a class of nearly one hundred pupils in the first year class

in the academy, about eighty-five per cent were found to have no idea whatever, or else a very crude notion, as to the placing of the decimal point in multiplication and division of decimals. This is given as only one of many faulty operations observed. It might be mentioned how some could not add and subtract the most simple fractions, or how still fewer could not divide 2/3 by 3/4.

The teachers of physics and chemistry in the Armour Scientific Academy state that one-half of the students who fail in these subjects do so because deficient in arithmetic knowledge. As an illustration, the majority when given the formula for the volume of a cylinder, $V = h \pi r^2$, and given the values of h, π and r, could not accurately find the value of V.

The accumulation of facts as to the preparation in arithmetic has forced upon the department of mathematics the teaching of arithmetic. We looked into the question carefully and decided against putting in a special course in arithmetic to extend through say one term. It was thought best to do some systematic work in arithmetic through the two years given to the study of elementary algebra, and plane geometry. We then prepared a pamphlet of problems, such as we considered best suited to bringing out the points we wished to emphasize, and in which the pupils were deficient.

These problems consist of many examples where operations alone are emphasized. Others have to do with metric and English measures. We included very many problems where substitutions are made into physical and geometrical formulas, and such as occur in chemistry. Some of these problems are assigned on nearly every day to be solved and handed in. An answer correct to a certain number of decimal places is required instead of a surd form, and the work is carefully criticised as to form and method. I might state here that all our problem work in mathematics is handed in and inspected, each instructor having a student assistant to help in this. Every few days at least a part of a recitation is spent in arithmetic. This arithmetic work is only just begun, but we hope to find that it will overcome the deficiency now so manifest. I should like to advance right here some reasons why the students are so poor in arithmetic.

It is generally conceded that there are two reasons for the teaching of arithmetic: (1) to develop skill in the handling of numbers and a practical knowledge of them; and (2) to train the mind to right thinking. Some years ago there was a marked change in teaching of arithmetic. The Speer method was put forward and every teacher was looking for something new in the way of method. The subject was made interesting, and the pupil's wishes and not his needs were consulted. As was stated by one of the prominent teachers of arithmetic in Chicago seven years ago: "The processes to be taught in arithmetic should be determined by the child and not by the educated teacher." And further, "Teach no part of arithmetic mechanically."

The result of all this was that the pupil had a merry time, but learned very little arithmetic. We are now just far enough removed to be reaping

the full benefit. The pupil's mind may be as well developed in analysis, but the practical work with numbers has been sadly neglected, and what we may call the mechanical part of the work is very crude. But when all is said and done, we have to deal with these pupils. They must be prepared to do the mathematical work in their physics and chemistry. However, we hope and trust that the training in arithmetic in the future will be better than that of the immediate past. It is not the function of this paper to outline how this is to be brought about; but allow it to be said that it will probably come about in part by the use of more sanely prepared text books than many of those now in use; and by a less scattering of the ideas while pursuing the subject. As Dr. David Eugene Smith says: "Of late we have been letting arithmetic slip from our hands because we could not justify the general arrangement of the books so at variance with our present life. That better computers were produced forty years ago than now was not owing to the dull rules, the stupid principles, and the absurd problems of that day; but because the work was definite, the teacher and the pupils could get their bearings, the curriculum was confined to the 'Three R's,' and this particular 'R' had its share of the time. Make the new arithmetic as definite as the old, preserve the best of the topical arrangement, give enough problems and let them appeal to the common sense business man as genuine, and to his child as interesting, and the arithmetic of the future will be the best that the world has ever seen."

To return to algebra, what we need is not to train the pupil to juggle with the equation, but to train him to recognize the relations of things. The equation should mean something. Any means or device that will aid the teacher in showing the meaning without causing the pupil to lose sight of the subject is legitimate. Use balances, drawings, discuss meaning, give definition, illustrate physical meaning, do anything which you as a skilful teacher can; but be very careful that the attention of the pupil is not taken from the equation, and that he does not think he is only measuring saw-dust.

Solve problems often in the abstract, and pass to the concrete. Require pupil to state result in words, and tell physical meaning. Work carefully to lead him to see that we can thus make rules, and find results from given data. The comprehension of the physical meaning of formulas can be made clear by thus translating them.

Dwell upon fact that much of our language of mathematics has come about by agreement and convention; *e. g.*, the meaning of exponents, and the method of expressing varies as.

In our courses, just as when we are teaching algebra, we make everything else subsidiary; so when we are teaching a certain subject of algebra, that subject is in the lime light. But this does not prevent us from constantly recalling other subjects. For instance, when we are at complex fractions in particular, factoring and equations may be in the assigned lesson. In our review algebra when taking factoring, we always solve quadratic equations, including the most general case, and do it by factoring, which, of course, requires the factoring of $ax^2 + bx + c$, and in particular cases

involves surds and imaginary expressions. Much is made of the remainder theorem and its use. The formulas of physics are introduced and the notation of these is used instead of using only the staid old letters a, b and x, y, and z. Not only are numerical values substituted into formulas, and accurate results required; but a few explanatory remarks are given, and in some cases formulas derived. In other cases certain forms of a formula are given and other forms deduced. Much of this we have in mimeograph form. While we do not actually spend time during the first year in making geometrical drawings, we use much of geometry. The facts regarding a right triangle and other forms in plane geometry, as well as those of cubes, cylinders, etc., are known or readily developed. Problems are solved which involve these facts and principles.

In plane geometry, which continues through one year, we use the heuristic plan in demonstrations. A text book* is followed somewhat closely, but it is one in which all the proofs are omitted. The instructors are all unanimously in favor of the text. Better results are obtained with it than we have ever secured with the common text. This is especially noticeable in the pupils' ability to attack a new problem, and make something of it. He has developed initiative. The use of this text requires some more time on the part of the teacher. In particular at the beginning must the progress be slow and sure. Much construction and some of what might be called laboratory work is done from the beginning. Each pupil is required to secure a note-book, protractor, compasses, dividers, rule to metric and English scale, squared paper, and a hard lead pencil. He is given work in comparing the two systems of measure, construction of angles, triangles, parallels, and numerous other problems. Vector numbers are discussed and used in finding composition and resolution of force and velocities. Sines, cosines and tangents are used to some extent. Much use is made of algebra and thus it is at least kept in mind during the year devoted primarily to geometry. Many problems are solved involving algebraic equations, simple, quadratic, and simultaneous. Problems of computation are used where the results to a certain number of decimal places are required. And do we not secure better results when algebra is thus taught with geometry than when the two subjects are made co-ordinate for say the two years?

Solid geometry is studied for the term of three months. Much is made of the subject of loci, and the generation of surfaces and solids by revolution of lines and surfaces. In this connection algebra is constantly used, and the ideas so useful in the more advanced mathematics are engendered. A great many of exact computations are required here, and many of the least useful theorems are omitted.

Trigonometry is the subject above all others of the secondary courses in which the pupil realizes that he must use the very best that is in him.

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*The text used is Hopkins' Plane Geometry.

But few students do the Freshman work in the College of Engineering until they have taken trigonometry in the Academy. So true is this that most students who have studied trigonometry elsewhere take it over in our classes when entering college. The particular parts which are of most use in analytical geometry, calculus, and mechanics, are made the subjects of most careful study. Logarithms are first taken up here, and much time is given to evaluating of forms which arise in calculus and mechanics.

It is seen, then, that at Armour Institut of Technology a very close correlation is made between arithmetic, algebra, geometry, and trigonometry; and that the relation of all these courses with physics and mechanics is a reasonable one. In its turn each subject in mathematics is in the lime light, but not to the exclusion of the others from any consideration. Much of what may be called laboratory work is done, but not so brought forward as to cause the student to lose sight of the mathematical subject in hand. We constantly keep in mind that we are preparing students primarily for a course in engineering. This forces much emphasis being laid upon accurate computations and the practical side of the subject.

If it were not outside the sphere of this paper, it could be shown that just as close, if not closer, relations exist between the corresponding branches in the College of Engineering of Armour Institute of Technology. Perhaps we have an advantage over many schools. In many ways the conditions are ideal. Close and cordial relations exist between the different departments. The same instructor in mathematics may be asked to teach any subject from elementary algebra to mechanics in the Junior college year. Each one thus knows exactly what comes before his subject and also what is to follow to the end of the line. He knows just what to expect to be well understood, and what to lay particular stress upon.

In the foregoing a simple statement of facts and work being done is given. Nothing is done in Armour Scientific Academy that could not be done in any first class high school. We may tend toward the conservative, but we honestly believe that we get results. The corresponding work at Bradley Polytechnic Institute at Peoria, Illinois, and Lewis Institute, Chicago, is very similar and they too believe they are accomplishing excellent results.

ENGLISH CONFERENCE

No formal papers were presented, but teachers met for presentation of difficulties and for free conference on methods and aims in co-ordinating and conducting the various branches of the work in English Composition and Literature.

HISTORY CONFERENCE

PRINCIPAL WEAKNESSES OF FRESHMEN IN HISTORY, WITH SOME CONSIDERATION OF THE REMEDY.

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Among the students in our introductory work in history there are now and then those whose unsatisfactory work may be due to some physical ill: their pale face, or hollow chest, or languid air possibly accounts for their small achievement. At all events they are entitled to suspense of judgment, until some physician may have given them a fair chance with their fellows. Others, again, are simply mentally unable, their birthright of mind being —pathetic to say—but as a mess of pottage. No other diagnosis tells why one who has been at work on the middle ages for six or eight weeks should seem really puzzled when told that the Mediterranean was not the Holy See; or how a student who had been over the same course twice, and had really worked, could then write of the Arian-Athanasian controversy that "In the fourth century there were two great parties in the church, the Arryans and the Athenians, who differed on all subjects but one—they agreed that gesus was a son of god." For such unables there can be no solace, save that which lies in the bliss of ignorance.

But if we eliminate these two weak classes,—the physically ill because they are provisionally negligible, the mentally unable because they are hopeless under any circumstances,—there remains with us a third group of defectives: those who are sufficiently endowed yet cannot utilize their latent powers, persons who are really susceptible of education but whose minds and souls are not developed in any measure befitting their years. Just what percentage of those who elect our introductory course belong in this group it is impossible to state; but it is true that they are enough in quantity largely to determine the quality of the entire class. These are the students I have especially in view now. To set forth the principal defects, or weaknesses, they show may prove of service to those in charge of the work of the schools; since while what is said may contain little, or possibly nothing, that is new, nevertheless a plain statement of some conclusions drawn from several years' experience with college freshmen may focus attention upon

certain deplorable characteristics of many of them which, it would seem, might be at least partly removed by improvement in the preparatory work.

Possibly the most fundamental weakness prevalent among such students is that they lack the habit of having accurate knowledge. I do not mean simply that they have no accurate knowledge on this or that question which may be propounded to them; any one may easily find himself in that condition. I mean rather that they are not accustomed to know much of anything in an accurate way; that it is not a habit with them really to know even that which they are willing to profess to know. At the end of a week's work on the Germanic invasions of the Roman Empire, they may not be able to give an exact account of a single step or event in the career of any one of the invading peoples, or know that the Huns were not Germans; and yet they may be quite ready to talk about the Visigoths or the Vandals for five or ten minutes. After laboring for some time over the reform movement that centered in the monastery of Cluny, they are likely to write, not without fluency, about the reforms of Mr. Cluny. One of them—or possibly this person should be enrolled with the unables—has stated that "Islam was probably the first real man to think along the lines of Mohammed." Another recently gave out the remarkable information that "When we speak of the Slavs we mean the race or peoples that lived on the south shore of the Mediterranean. The Slavs were dreaded invaders and it was thought they were pretty strong. By the times of the crusaders they had gained some footing in Italy and Africa, and after the first crusade had started, they had taken a part in taking Syria as the ones did that stopped at the town opposite Syria." One special characteristic of the unscholarly youths who say such things is their apparent inability to get out of a sentence or paragraph what it really says. Have them read a paragraph or two on Justinian's codification of the Roman law, and supplement that with a half hour's explanation of just what Justinian had Tribonian and his colleagues do; then several of them will be ready to tell you that Justinian was the *author* of the Roman law. Place before them a clear explanation, not a page in length, of the origin of the "Forged Decretals," and I hesitate to say how many will fail to see from it just what gap these documents were designed to fill.

It is not that such students are not interested, nor simply that they do not work enough. Under either of those conditions, the phenomena in question might be adequately accounted for without going farther back than the University course in which they occur. Doubtless it will always be possible in the University as elsewhere to improve the treatment of this or that subject, so as to arouse greater interest and secure more effective work. But with the ways of treatment followed so far, such students are frequently profoundly interested; it is not uncommon for them to work much, and with enthusiasm. Their mental activity, however, is apt to take the form of discussion rather than knowledge. They will reason about the matter in hand, and consider with veritable avidity what might, could, would, or should be;

but at the same time they will avoid facts as they would poison. Sometimes they will seem all but to consider it an insult to be asked for definite, specific information. In sum, what many students of capable endowments are able actually to know, when they first come to us, and to tell to others so that they also may know it, is so little that it is hardly respectable. They need to talk but a moment before one is compelled to question how they have done their work in previous years, whether they have been trained to do much of anything thoroughly.

A second fundamental weakness among the students whom we are now considering is that they have too little ability to make use of facts, once they get possession of them. If perchance they learn definitely that there was a battle of Adrianople and exactly between whom and when it occurred, they are quite apt to know nothing of what led up to it, or to have no definite curiosity about what significance it had either for the Roman state or for the Visigoths. If they learn to spell Attila's name—I have known one student to spell it four different ways within five lines—and to know that after Attila's time the Huns achieved little in Europe, they still fail to ask, to say nothing of understanding, so simple a question as just how did the great leader's death affect the fortunes of his people? Or they will learn conclusions, make statements of greater or less generalization, and have not the slightest evidence for them. One of our hardest tasks is to develope in them a realizing sense that such a statement as "Charlemagne conquered much territory" demands in proof specific mentions of at least some of his conquests; and quite frequently it is a case of developing, not a realizing sense, but simply a mere acquaintance with that habit of mind which calls for proof. Such students will tell you that Philip Augustus greatly extended the royal possessions in France, and then if asked what evidence they have of Philip's success they will say, not that he gained Normandy and Maine, among other lands, but that they read it in a book. If asked what facts bear out their statement that Charles V of Germany acquired many regions by inheritance, they will possibly offer one or two irrelevant observations, sit down with an air of surprise that you should be so cruel, and tell their friends that you ask such funny things. Clearly the art of asking historical questions of facts—I do not mean asking them of documents primarily, but of the facts to which documents bear witness—this art is none too much cultivated in the circles in which many of our freshmen move before they come to us. And yet this art, practiced until it is a habit, is the indispensable means of making knowledge of facts worth while. Without it no one can attain the higher ends of the study of history. Without it no one can know in an understanding manner where we now are with our states, and literatures, and religions, and what not, and in what direction we are moving. Without it no one can ever cultivate, in any true sense, his judgment of cause and effect "as cause and effect take place in human affairs."

These, then, are the principal mental ailments our freshmen in history are heir to. If I mistake not, the other shortcomings they exhibit, such as

poor spelling, slovenly writing, inadequate vocabulary, talking off the point, and the rest, would all but disappear were each student but sufficiently grounded in the habit of knowing his facts accurately and in the equally essential habit of putting them together in a manner to reveal something of their historical significance. Furthermore, after patient observation of their habitual shortcomings, after a conscious and persistent but none too successful endeavor to reduce their lapses in knowledge and understanding to what might seem normal frequency, especially after often all but sacrificing other aims of college work in order to fight the plague of inaccuracy, the instructors in History 1 and 2 at the University feel justified in the conclusion that at least a considerable share of the responsibility for such conditions rests with those who direct the work of the schools.

But if it be granted that improvement of the preparatory work would help much to remove the primary causes of our troubles, just how may we expect to secure that improvement? To begin with, in what measure should we depend for it upon better means with which to do our work? Certainly there has been in late years much improvement in the means for the study of history in the schools, and progress in this regard is still going on. Any teacher whose experience goes back over a decade, or even half a decade, knows that he has much less reason now than formerly to complain of the text-books. These aids have not only increased in number and kind, but as a rule are better in quality. Thanks to the combined labors of historical scholars, historical writers, and practical teachers, they are now numerous and varied enough to accommodate different grades of work and different tastes or local demands among teachers and schools. And with better text-books have come numerous other aids; appropriate collections of sources, teachers' guides, in some places special libraries for collateral reading, better maps, and illustrative pictures. Yet I, for one, am distrustful of expecting too much from our acquisition of better tools. To be sure we have right to think that, other things being equal, we can do better with modern machinery than with the antiquated mechanisms employed by a preceding generation. Wheat, of course, can be separated faster with a thresher than with a flail. But after all, if we are to seek renewed strength primarily in improvement of the tools we employ, I am convinced that the fundamental weaknesses which now exist will always be showing themselves in undue proportion. We must look chiefly, I think, to the persons who are using the tools; to the printer rather than to his press. One can easily comprehend that the finest printing presses would not profit much in the hands of a Hottentot; but it seems just as true, though not quite as easy to see, that good text-books and plenty of collateral reading are of little avail in the employ of an unfit teacher. It seems to me as clear as day—and every one here will surely agree with this—that no one who is not himself imbued with the spirit of accuracy and thoroughness can inspire such a spirit in the young. And in like manner, he who learns by rote, and has not the habit of inquiring into the significance of things, can never train others to ask of thoughts and of deeds

and of events what led to them and what they in turn led to. So, better the tools as we may, in last resort, our salvation will depend on those who use them.

The truth is, indeed, that with all their recent improvement, the principal tools at our disposal,—that is, our text-books,— are of such character that the teacher in history has a greater measure of responsibility for what is to be done by pupils than has the teacher, if not in any other subject, certainly in most other subjects of the curriculum. The manuals in algebra and geometry hold between their own covers the matter which is counted essential for the subject and grade to which they apply. The first-year books in Greek, Latin, German, or French supply material that is definite—even graded—throughout, and they are adequate enough of themselves to give need only of a grammar besides. The manuals in physics and chemistry call for much supplementary work in the laboratory; but the principles they set forth are limited in number, are especially susceptible of definite statement, and by experiments may be actually seen, or touched, or smelled. The personal factor necessary in the successful teaching of a piece of literature can hardly be exaggerated; yet the Cicero, or Virgil, or Shakespeare that is read in class is fully printed out on the page that lies before both pupil and teacher. Our history text-books, on the contrary, do not contain in any such clear and unmistakable form the matter that we ought to teach, and that our pupils ought to get. Whether they should or not, as a matter of fact they do not. I know of no one of them, at least in European history, that is written as history is best written. Not more than one of them so restricts the number of questions it treats that it has space always to set forth evidence as well as conclusions. Only rarely, not customarily, do they bring into the light reflected by broad statements the details of human life, the actual thoughts and deeds of the men in view. They are, even at their best, but guides, bearing somewhat the relation to history that histories of literature bear to literature. And unless the teacher who uses them is able to go to the history to which they guide, his pupils will have as much reason for execration as those unfortunates who are dragged or whipped through some Crutwell or Shaw, without time and without a cup to drink from the springs that well along the course, just out of reach.

I run the risk, however, of merely expressing a commonplace if I only insist that the chief hope of a reasonably efficient remedy for the defects of our preparatory work lies with the teacher rather than with the books he uses. That is altogether fundamental, you may say, but quite evident. The fact is, it is like the golden rule, and other such principles set forth in the Bible: the rub comes not in knowing it but in applying it, not in accepting it but in seeing just how to live up to it. Is there, then, some plain course to choose, which when sanely followed surely leads to increasing effectiveness in teaching? Is there some particular, definite aim, the faithful, wise pursuit of which will not only keep him who is teaching on the

right road but insure at the same time that the pupils following after him arrive at a worthier goal than many of them reach now? These questions, I think, must have an affirmative answer, if we but recall that, in the last analysis, the processes which are fundamental in the teaching of history are first fundamental in the writing of history; just as the course of thought followed in teaching how to build houses, or bridges, or what not, should first prove safe in the actual building of such things; or just as the methods followed in classes in painting must first hold good in the making of pictures.

Now he who takes part in the writing of history is necessarily occupied in one or the other of two ways: he does something either upon the immense task of establishing facts or upon the still more immense task of treating in a historical way facts that are already established. If he has good principles, before he engages in putting facts together to reveal their connection and historical significance, he aims to know the facts he works with. Whether he establishes these facts himself, or accepts them as established by some one else, he endeavors to have, with reference to any given matter, a clear, appreciative, objective knowledge of just what persons or people were concerned, just what was thought, or said, or done, and just when it happened. Not until he is thus equipped can he safely undertake to tell the true relations of things, the whences and whithers of the thoughts and acts he has in view. On the other hand, once he knows some facts it is incumbent upon him to try to interpret them historically, if he would gain the real fruit of the historian's work. He must go on to trace if he can what they grew out of and what they grew into; for in the measure that he stops with unrelated knowledge will his knowledge be of little power. But the point now is, are not they that are thus occupied,—they, namely, who actually practice the science and art of history,—are not they the persons whose principles and ways of work every teacher of history should have constantly in view? Are they not carrying on, in a manner to be the guides of others, those very processes which should be as paths of life in historical classes? Where indeed may the teacher of history better go to develope independent and trustworthy mental customs, to cultivate the scholarly habits of knowing things accurately and understandingly, than to the great school conducted by those who do historical work? I for one shall expect to see the work in history classes improve in about the proportion that those who direct those classes become real doers of historical work.

This doing of history to which I refer does not mean necessarily that we should all be trying to write a great book, like Mr. Green's *History of England;* nor that, on the other hand, fault of material or equipment with which to do the big things, we should all turn to seeking out obscure facts, say of local history. Circumstances should determine what each of us should be doing. It may be that many of us should occupy ourselves all but solely in patient study of the models of the masters, as the art student who places his easel week after week before a Holbein or a Rembrandt. Or possibly we should be gathering, from different quarters, already established

facts upon some significant person, or idea, or condition, or event; with the purpose, after knowing such facts, of trying our hand at putting them together in a historical way: the tasks in this direction that may be undertaken with profit are, and doubtless always will be, innumerable. Possibly again, some of us should be spending considerable time in searching for facts yet unknown, with which to enrich the present store of knowledge. In any case, whatever our individual needs or tastes, would it not advantage each of us always to have in hand some definite bit of historical work? Thus we might constantly give to our activities as teachers not only trustworthy principles, but also the refreshment and vigor that come with exercise and creative effort.

In conclusion, if it be clear that our University freshmen show in their work in history that too many of them are weak in the scholarly habits of knowing accurately and understandingly, and if also it appear reasonable to attribute a considerable share of the responsibility for such weakness to those who direct the preparatory work, it still may seem that the remedy here advocated is so difficult and slow that to contemplate it is only discouraging. Slow it undoubtedly is. But the changes in human things that are strongest and have the longest life are not those we enact suddenly, but those that grow, those that we cultivate from one generation to another. Moreover, there are indications that the application of this remedy is already well begun among us. The schools insist more and more generally that the teacher in history shall be properly qualified for his work; the historical departments at the University have organized courses which give to undergraduates increased opportunity to get practical experience in doing historical work, and the elections in these courses are constantly increasing; some students remain in the University for a year or more of graduate work, others return for study after a few years; many teachers attend the summer sessions of the better universities; these phenomena, among others, mark a strengthening tendency among us to be ourselves expert in that science and art which we would impart to others. And I for my part refuse to be discouraged. I look rather with confidence toward the day when we all who are teaching history shall be first, in an appropriate sense of the phrase, doers of history.

MODERN LANGUAGE CONFERENCE

THE ESSENTIALS OF GERMAN COMPOSITION

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Where is the modern language teacher who does not groan, audibly or inwardly, at the very mention of composition, or who has not done so at least at some stage of his or her experience? And the cause for such a manifestation of discomfort is not far to seek. Of all features of the work in Modern Languages, the teaching of composition is the most laborious and nerve-wearing, giving the smallest results for the greatest expenditure of energy and patience. It is the most difficult subject in which to obtain and hold the attention of the learner, to arouse even a semblance of enthusiasm on his part. The pupil approaches the task with a listless, indifferent air, does the prescribed work as carelessly and as infrequently as the watchfulness of the teacher will permit, makes the same errors with maddening precision of recurrence, and meets all reckonings of his shortcomings with an air of injured innocence which in itself blights all hope of future improvement. In brief, composition means drudgery for both teacher and pupil, the teacher, however, being the greater sufferer in proprotion to the conscientiousness and high ideals he brings into his calling.

The reason for this distressing state of affairs may not be so remote or so intangible as is generally supposed. I believe it lies in the disregard of the essentials underlying the *teaching* of composition, for in no other feature of our work is the wise guidance and judicious help of the teacher so necessary. I am more than ever convinced of this since examining an interesting collection of statistics recently obtained. It is an accepted theory that pupils greatly dislike all composition work. To my surprise I found that it is not so much the dislike of the work itself, as the disinclination to spend the required time upon it, that makes it irksome. "It takes so much time,"— how to remedy this almost universal complaint, is indeed the question. For the trouble does not lie in the length of the assigned task, it is far more deep-seated, it lies in the spirit of the times, a disinclination to devote the time and patience necessary to do any task well. The "get-rich-quick" methods have invaded not merely the world of finance. Then, too, another secret and often unconscious reason is stated by a pupil who writes: "I do not like composition work because it shows so plainly what I do not know. In reading or translation I can make a better showing with less labor." So there is evidently a need of developing a moral sense for honest and thorough work. A further point brought out in these statistics is, that the kind of composition work has a strong influence on the mental inclination to do it. If pupils have tasks which they believe to be *practical*, they will do them willingly and even gladly, for they are indeed children of the age. Of

course, the pupils' judgment is not always a safe criterion, but we, with our wider experience of life, our authoritative position, can do not a little to bias such a judgment in the right direction. Errors in composition are often a discouraging element to the learner. Yet nine times out of ten such errors result from heedlessness rather than from ignorance. Let this fact be tactfully brought to the pupil's notice, and he will exert greater care to avoid such mistakes. In other words, he needs to be inspired with a feeling of confidence in his own capability, and with a sense of duty to properly exercise this capability.

So I repeat, that in no other feature of the work is the wise guidance and judicious help of the teacher so necessary. But this presupposes on his part a comprehension of the fundamental principles which govern the nature of the work. The essentials underlying the teaching of composition are four in number, and are given in the order of their importance. First, foremost, and most emphatically, the attitude of teacher and pupil towards the subject; secondly, the aim to be pursued; thirdly, the material with which to pursue this aim, and lastly, methods of utilizing material.

In the attitude with which the subject is approached, lies the key to success or failure. The prevailing tone in this branch of our work has already been indicated, and I hope I may be pardoned when I say that, judging from my own experience and from observation, this picture is not unduly exaggerated. The attitude of the teacher is largely responsible for the attitude of the class. To show that the work is disagreeable, disheartening, not of primary importance, is fatal to all efforts on part of the class to exercise care and good will in their tasks. Much can be done to impress these young minds with the importance of the lesson by the spirit in which we teach it. Yet the spirit which is least seen and most needed, undivided and earnest attention, is the primary requisite to successful composition work. Undivided and earnest attention on part of the teacher, to point out and explain all important and essential points in the lesson to be prepared; concentrated attention on part of the pupil, to absorb and retain the explanations given. *If the pupil is made to realize from the very beginning that he is to be held strictly accountable for all these points,* then the battle is half won. The forced attention he gives at first, will soon become natural through habit and interest. In the early stages of the work it is advisable to allow the taking of notes, in fact, to require it; later, the memory alone should be the storehouse. It is perhaps needless to say, that the teacher must limit the number of such important points and use discretion in their selection. But he must be indefatigable in enforcing and reviewing the lessons thus taught.

Then, too, liveliness of instruction (not so difficult since we are dealing with a living language) is an important factor in securing attention. By liveliness of instruction is meant, not merely vivacity in presenting the lesson at hand, but also a common activity of both teacher and pupil, and a rapid rotation of pupils in the participation of the lesson. Perhaps in no other line of the work is it so important that the teacher should be regarded as

authoritative, therefore let the wise teacher beware of subordinating himself to the text-book or material at hand.

And lastly, another important aid in securing the desired attitude, is the frequent and careful supervision of the pupils' work, with a subsequent explanation and discussion of common errors. This supervision should take various forms, blackboard work, correcting of tasks handed in, and tests or examinations at not too distant intervals. Nothing is so effective in combatting inattention and carelessness as the watchful eye of the teacher. Prose work in a foreign language is never easy, but for that very reason it affords the greater opportunity to arouse in our pupils the pride to conquer a difficult task, to innoculate them with a taste for the sweetness of such a victory. Then will come the mental growth and vigor which will stand them in good stead when school tasks become "things of the long ago."

What the aim shall be in our instruction in composition, is a question each one of us must decide for himself, and re-decide to some extent with every new class of students. However, the aim should be uniform with the aim set for the general course; it should be, in fact, a coherent part of it. And it should be strictly limited in scope. We must confine our teaching to the regular, the ordinary, the necessary features of the language; and yet "the stream of a living language is so wide" that even the regular, the ordinary, the necessary will assume well-nigh boundless proportions, which no amount of activity can span in the limited time provided in the high school course. Therefore the imperative need of fixing a modest, attainable goal, and then steadfast and iron determination in pursuing this goal. In general, I would venture to put as the aim to be reached in the second year of high school instruction, the ability to reproduce, in simple German or French, a topic familiar from the general work done or related to it. That is to say, the pupil should be able, at the end of the second year, to *use* correctly inflected forms, proper case constructions, and the correct word-order in expressing very simply put ideas. I stress the word "use" purposely, for I mean, not only in written work should he have this ability but also in oral work. Here, however, it is well to bear in mind that in written work there is time to think and the eye to see errors, so we must not become impatient when in the oral work, correct forms come haltingly and only after several efforts. We have reason to be satisfied, if at this stage of the instruction, the learner perceives his errors and attempts to correct them. To express even the simplest ideas in a foreign tongue, requires a mastery of numerous norms.

In coming to the subject of material for composition, we find ourselves embarrassed by the superabundance which makes selection difficult. This material may be roughly classed under four headings: (1) composition books, (2) texts furnished with prose based thereon, (3) anecdotes or stories, (4) material selected and adapted by the teacher.

By prose composition books I mean such which take up, in some systematic order, grammatical principles, and furnish drill thereon in one form or

another. I am well aware that many composition books, so called, are a mere collection of anecdotes progressing in length, and sometimes in difficulty, with the number of the page, but lacking all inner continuity of grammatical features. Such books should be placed in class three, anecdotes. A good composition book is the easiest mode of teaching the subject, and perhaps the safest for the inexperienced teacher. Its definiteness of plan, its logical development of grammatical features, the suitable material it provides, are points in its favor. But for the high school, it is not without counterbalancing disadvantages. It is apt to subordinate teacher to textbook. It may present drill or material not needed by the class, and fail to give such as the class does need. Then, too, the material contained in such a book, is frequently too abundant for the time at our disposal, and is most often not simple enough for the second year work. Furthermore, such a book is generally adopted for a number of years, and as time passes, the younger generations have recourse to exercises already prepared, and unfortunately carefully preserved, by their predecessors. And lastly, such a book is a harassing limitation to the versatile and progressive teacher, a dangerous sedative to the inactive one.

Many of our second year texts are now provided with prose based thereon. But one needs to be wary of it. Not a small part of such prose will turn out to be dull, foolish, incoherent, devoid of all underlying principles, when put to the test of classroom work. It is sometimes too easy, but more often, too difficult for the grade of the text. It rarely uses the connected form; it introduces no variety of treatment. Therefore it should be subjected to close scrutiny and used with discretion.

Stories for prose work are very tempting because they are usually entertaining and interesting to the pupils. It is also claimed that they increase vocabulary and furnish variety of expressions and material. But just here lies the danger in using anecdotes or stories to any large extent; the vocabulary, the expressions, the material are too varied, not sufficiently re-occurring to make more than a fleeting impression on the learner's mind. Thus they fail to create a feeling for the language, a familiarity with the vocabulary and the idioms; and so, very few new words are added to the pupil's active vocabulary, nor will his supply of idiomatic expressions be materially increased. I doubt very much if in the second year of instruction, the reproduction of a miscellaneous group of anecdotes will teach the pupil to write with even a moderate degree of correctness. Later in the course, anecdotes and similar material can be used, for several reasons, to better advantage.

Every teacher knows best just where the weakness of his pupils' work lies, and consequently can minister to their needs as no stranger can. The wide-awake teacher has it in his power, therefore, to select, adapt, or create such material as is best and most naturally suited to the needs of his classes. Of course, this means the exercise of some skill and discrimination, and it means more work for the already overburdened teacher. And yet the results are so gratifying that the additional labor brings its own reward,

closer attention, greater interest, better work. A good reading text should be able to furnish all needed material and variety of material for composition. If the text is already provided with fairly good exercises, use them if you wish, supplement them as you see the need. But better still, plan your own exercises. These should always illustrate or keep in view—not, however, with disagreeable prominence—some definite grammatical feature; they should be progressive, and should present opportunity, in various guises, for frequent repetition of important points. The reading and subsequent writing of certain passages in various tenses and persons; the changing of direct to indirect discourse and vice versa; the transforming of colloquy into narrative form; free reproduction; questions and answers; these are only a few suggestions for an infinitely useful and abundant supply of material for daily work in composition, which at the same time will not distract from the general character of the recitation, while it provides a welcome variety in class routine. You may not call this composition work, but it is the using of the foreign language itself in a most profitable manner. And is not this the aim in the course? For more formal work, such passages as apply to every day life may be made the basis of a series of exercises. (Allow me to state, by way of explanation of what follows, a pet theory of mine, namely: in the earlier stages of the work in Modern Languages, a limited amount of really good material, molded into as numerous and diversified forms as possible, is productive of better results than an abundant and diversified supply of material. And let me plead right here for the connected form, and against disconnected sentences). Take, for example, in such a text as "Der Schwiegersohn," the passage describing the living room, and that picturing the doctor's study. These will furnish a good and practical basis for such a series of exercises. The preliminary conversational drill may be followed by a reproduction of the passages for which the teacher gives the English. This same material may be remolded into dialogue form, again on a given English basis. Unfortunately the colloquial form is very commonly neglected in composition work, and yet nowhere else is there such an opportunity for idioms, for liveliness of expressions, for originality and spontaniety, for development of the Sprachgefühl. And pupils are very fond of dialogue and interested in it, for it appeals to them as something eminently practical and useful. As a third lesson in such a series the words, expressions now quite familiar, can be used by the pupils, with a judicious addition of new ones, in writing a description of their own rooms. It is well to give an outline for this lesson in order to secure a certain uniformity of length and treatment. And lastly, the learner might try his skill in turning this same material into original dialogue based on an incident or episode which the teacher should indicate. Perhaps I shall make this scheme somewhat more concrete by illustrating such a series of exercises from actual work done by pupils. For the first and second exercises the English basis was given; for the third exercise, a very brief outline; for the fourth, the episode of roomhunting with the assistance of a kind friend on coming to the

University for the first time. The errors are reproduced as they occur in the original manuscripts. For number four no preliminary oral drill was given, which, in part, accounts for the more numerous errors. The series represents the work of different pupils whose exercises are chosen at random.

I. DIE WOHNSTUBE.

Die Wohnstube war das gerämigste und hellste Zimmer in dem Haus. Sie war auch sehr schön ausgestattet, denn der Schneider hatte sowohl Schönheitssinn als Mittel. Die Möbel waren nicht alle neu, aber die altmodischen Stücke waren nicht nur solid sondern auch behaglich. An den Fenstern hingen bunte Vorhänge aber darüber waren auch weisze Vorhänge, welche die etwas grellen Farben derselben dämpften. An den Wänden waren einige gute Bilder, manche in vergoldeten, manche in reich geschnitzten Rahmen. Das schönste Bild war vielleicht das, welches über dem Sopha hing und Kaulbachs "Homer und die Griechen" darstellte. In der Ecke über dem Schreibtish war eine Marmorbüste des Zeus. An der einen Wand waren niedrige Repositorien und hier standen in langen Reihen hunderte von Büchern, einfach aber dauerhaft eingenbunden. In einem Gestell neben dem Schreibtisch waren die Wörterbücher und Bücher deren man zum Handgebrauch bedarf. Das bequeme Sopha und einige weitarmige Sessel waren mit grünem Ledertuch überzogen. Ein groszer Spiegel von Epheu beschattet hing zwischen den Fenstern. Davor stand ein Teetischchen mit zierlichen meiszener Tassen. Also konnte man hier sowohl Geist als Körper stärken.

II. EIN GESPRACH AUR DER STRASZE.

"Ei, guten Tag, lieber Freund, wie geht es Ihnen?"

"Danke, sehr gut, und wie befinden Sie sich heute."

"Ach, nicht sehr gut."

"So? Das tut mir leid. Was fehlt Ihnen?"

"Nun, ich habe mich erkältet. Meine Wohnung ist sehr unangenehm."

"Was Sie doch sagen! Ei, wohnen Sie nicht mehr in jenem groszen Palaste wo Sie letztes Jahr solche schöne Wohnung hatten?"

"Nein, nicht dieses Jahr. Meine Mittel erlauben es nicht. Ich muszte eine billigere Wohnung nehmen. Die Zimmer sind etwas weniger geräumig and die Möbel sind sehr altmodisch."

"Aber Sie wissen doch dasz altmodische Möbel oft sehr solid und bequem sind."

"Das ist wohl wahr aber meine Möbel sind Ungetüme. Die Sessel sind so unbequem und das mit Ledertuch überzogene Sopha so hart dasz man nicht darauf sitzen kann. Die Repositorien sind so hoch, dasz ich das oberste Fach nur mit Hilfe einer Leiter erklimmen kann. Es sind so viele Türen und Fenster dasz kein Wandraum ist. Also kann ich meine Bilder und Photographien nicht aufhängen. Sie kennen doch jene schönen Ansichten der Universität welche ich im Paris kaufte? Sie bewunderten sie so oft in meiner früheren Wohnung. Nun, die hängen in meinem dunkeln

Schlafzimmer. Und meine Sammlung von Biergläser, Tassen, und Pfeifen haben nirgends Raum."

"Armer Kerl, das ist ja alles sehr traurig. Aber trösten Sie sich. Ich komme bald auf Besuch zu Ihnen und bringe einige Universitätsfreunde mit. Dann halten wir ein kleines Gelage und singen die alten lustigen Studentlieder und Sie werden alle Ihre Sorgen vergessen. Aber jetzt muss ich beeilen, ich habe nämlich eine Klasse. Adieu für heute."

"Auf Wiedersehn!"

III. MEIN ZIMMER.

Mein Zimmer liegt mitten im ersten Stockwerk. Es ist ungefähr fünfzehn Fuss lang bei fünfzehn Fuss breit. Es macht einen behaglichen Eindruck wenn man hineintritt. Es hat ein groszes Fenster welches gegen Osten liegt und an dem weisze Vorhänge hängen. Zwei Türen öffnen auf auf andere Zimmer und eine auf den Flur. Die Wand hat grüne geblümte Tapeten. An der Wand hängen Bilder, Landschaften und Porträte Mein Lieblingsbild ist das, welches einen See im Mondschein darstellt. Das Zimmer ist mit Dampf geheitzt. Da sind zwei Schaükelstühle und zwei andere Stühle in dem Zimmer. Ein mit Ledertuch überzogenes Sopfa steht in einer Ecke, und in der anderen, ein Tisch auf welchem Bücher und Tinte und eine Studierlampe sind. Dem Tisch gegenüber sind Repositorien, in welchen Geschichtsbücher und Schulbücher sich befinden. Darüber ist eine mit grünem Tuch beschattete Konsole. Darauf stehen Tassen und eine Uhr. Auf dem Boden liegt ein dunkler Teppich.

IV. WIE ICH EIN ZIMMER FAND.

Ich war eben in Ann Arbor angekommen um die Universität zu versuchen. Ich trat auf die Statestrasze um eine Wohnung zu finden. Da ich die Stadt wenig kannte, war ich etwas in Verlegenheit, als ich eine bekannte Gestalt sah. Sie war meine gute Freundin Margarete, die in meiner Vaterstadt wohnt.

"Liebe Freundin," rief sie, "woher bist du gekommen, und wie geht es dir?"

"Das ist eine angenehme Überraschung," sagte ich. "Es freut mich dich zu sehen. Ich weisz nicht was zu tun. Ich wollte eine Wohnung finden. Was ist der beste Teil der Stadt für eine Studentin?"

"Oho," sagte sie, "Bist du hier gekommen die Universität zu versuchen?"

"Richtig," lachte ich, "Und du muszt mir helfen."

"Ich kenne gerade das Haus. Es ist das Haus wo ich wohne. Es sind zwe unbenutze Räume gegenüber meinen Zimmern, und sie werden dir gewisz gefallen."

"Recht gut," antwortete ich, "Also gehen wir."

Wir traten ungefähr fünf Minuten, als wir zu dem Haus kamen, wo Margarete wohnte. Wir stiegen die Treppe hinauf, und gingen in das Haus. Wir waren bei einer freundlichen Dame getroffen.

"Frau Neumann," sagte meine Freundin. "Ich habe meine Lieblingsfreundin gebracht, die unbenutzten Räume anzusehen."

"O, wenn sie wünscht," antwortete die Frau. "Dann kommen Sie, die Räume sind im zweiten Stockwerk."

Die Zimmer waren sehr schön und behaglich und bestanden aus ein Studierzimmer und eine Schlafstube.

"Die Räume sind sehr gut hergestellt," meinte Frau Neumann.

"Ja," antwortete ich, "und ich sehe dasz es gute Repositorien sind. Das freut mich."

"Auch sind die Möbel schr zierlich und behaglich, und sieh! solche schönen Bilder an den Wänden," rief meine Freundin. "Ja," sagte ich, "sie gefällt mir, und wenn der Preis nicht zu—

"Nur drei Taler die Woche," fiel die Dame ein.

"Dann," sagte ich, "ich werde die Wohnung nehmen."

These exercises, with the exception of number four, were first prepared in class orally, then written, usually in part only, under the teacher's supervision, thus giving opportunity for questions concerning words, expressions, grammatical facts. For the home task such an exercise was copied in a revised, corrected, and completed form. These papers were next examined, marked, and returned to the pupils for correction and discussion of errors, for which a part of a recitation hour is devoted. Number four was meant to serve as a test, hence no class preparation, aside from a few necessary suggestions, was given for this exercise. This explanation leads me to the last topic, that of method.

There is no single method, nor "best" method for teaching composition, nor is it at all important that one should be discovered or invented. For nowhere else in our instruction is the danger of dull routine work so great, nowhere else the necessity for new lesson-plans, for fresh spirit so abiding, just because we meet here our greatest difficulties. So we need for it all our best enthusiasm and interest, and whatever our methods, these need to be continually revised and imbued with new life. Experience and observation have been impressing on my mind two points as to method. In the first place, we leave our pupils too much to the intricacies of grammar and dictionary, to their ignorance of how to attack the lesson at hand, and their consequent dislike of composition work. Definite lesson-plans, preliminary oral drill, preparation, at least in part, under supervision, will result in clearer ideas, a firmer grasp on the material to be prepared; will result in a better understanding of grammatical features, and consequently, in more correct and encouraging work. Furthermore, I am inclined to believe that we have too much written work, or to express myself more exactly, we confine our teaching of composition too exclusively to written work. I fully appreciate the valuable lessons taught by well written and carefully prepared tasks, the habits of industry and neatness thus acquired. Pupils often prefer the written work to the oral and why? Because, not infrequently, it means a substitute for mental effort instead of an aid to it.

If the written composition is to be profitable, it must recall and put into visible form that which is already familiar and understood; it should be regarded as a means to fix this knowledge still more permanently in the learner's mind, to reveal any haziness or error existing there. In short, the written exercise should give definiteness and fixity to lessons already learned. But it is the oral work particularly which leads the pupil nearer to the language itself. I think it is Sweet who says, "The living spoken form of every language should be made the foundation of its study." And so, why not put the study of the language in a living, spoken form?

THE QUESTION AND ANSWER METHOD IN MODERN LANGUAGE TEACHING.

JOHN E. LAUTNER, PROFESSOR OF MODERN LANGUAGES IN THE NORTHERN STATE NORMAL, MARQUETTE, MICH.

Modern language instruction has undergone a revolution in the last two or three decades. It is not the province of this paper to give a history of this revolution. Suffice it to say here that the radical leaders of this revolution have rejected as worthless, or even injurious, the use of a grammar or text-book, translations from the mother tongue into the foreign and vice versa, and have tried to banish completely the use of the mother tongue from the classroom. Various names have been given to this method, as, among others, the "natural method," "conversational method," "the new method," "the direct method," etc. Meanwhile many of the conservatives and reactionaries have clung with persistent tenacity to the so-called "old method," "grammatical method," etc. It is our opinion that the extremists, as is always the case in radical changes, are gradually finding a medium ground. An adjustment of the two extremes is gradually taking place. Most of us are agreed, I hope, that the use of the foreign language in the classroom is no longer looked upon as heresy but as an absolute necessity. The same thing is true precisely of grammar. The question no longer is "either or" but How can we use *both* most effectively? This is *the* question before us. My own experience leads me to the firm conviction that a wise combination of the two methods produces the best results. The more thoroughly the fundamental principles of grammar are taught the better, and the more the actual living language can be used by the instructor and the class the better. But *how?* That is, as I have already said, the most difficult problem before us.

I wish to discuss for a moment a method by which the foreign tongue can be used in the classroom. I mean the Question and Answer method, or the Socratic method, as it is often called in Pedagogy. Now this is no new method, as you are all aware; in fact it is as old as instruction

itself. But this antiquity of the method does not argue against its efficiency. On the contrary, it is an argument in its favor. Then, too, it is not simply old but it is still used in all departments of instruction as one of the most effective methods. What *does* this method and what *can* it accomplish in modern language? To answer this question it is necessary to have some standard by which to measure its value. This standard is contained in the answer to the question, What does it mean to *know* a language?

An analysis of this question will reveal only commonplace truths, but they are essential to a correct understanding of the problem.

Language for our present purpose is in the main a system of more or less arbitrary symbols used for conveying ideas from one mind to another. These symbols are now of two kinds, viz., visual and auditory. A complete knowledge of a language would mean a complete knowledge of these symbols, *i. e.*, ability to interpret and use them together with a knowledge of their phonetic and *semaceological* changes which they have undergone in their historical development. In other words, we must be able to read, to understand, to write, to speak the language. We have therefore in the learning of a language four different processes, viz., Seeing, Hearing, Speaking and Writing, two of which are sensory and two motor processes. That is, we have two channels of "impression" and two of "expression."

We wish especially to emphasize the fact that these four processes are separate and distinct processes, *i. e.*, we may have mastered one of them and know nothing of the others. This statement is supported by the very common emperical observation that one can read and not speak a language, or one may be able to understand the speech of another and yet not be able to speak the language himself. Then, too, Physiological Psychology has emphasized the independence of these sensory processes by the localization of brain functions. As is well known now the visual centre and auditory centre are not located in the same part of the brain, so with the motor centres of speech and writing. Before we are able to understand and use with equal facility the written and the spoken word, associational tracks have to be formed between the centres of sight, hearing, voice and hand movements, connecting these various sensory and motor centres.

Since these four processes are separate and consequently require different exercises to develop them, the question naturally arises which should be developed first; or should they all be and can they all be developed simultaneously? Is one process of greater importance than the others and hence should receive the emphasis or even exclusive attention? This is one of our great problems in modern language work. Before the invention of printing the auditory symbols were unquestionably of greater importance than the visual symbols, for the human voice was then the chief means of conveying ideas from one mind to another. In modern times, however, the specific social environment in which the individual lives must determine which of these is most important. For example, it is obvious that a resident of the United States will very likely not attach the same degree of import-

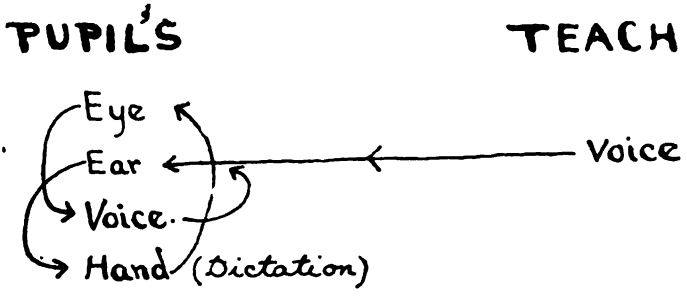
ance to the ability to speak the German language as a resident of Holland or Switzerland.

There is right here a very fertile field for the physiological psychologist. He ought to be able to prove the relative tenacity of visual, auditory and motor symbols or tracks, and hence give us a scientific foundation upon which to base our instruction. He ought to be able to show us to what extent each one of these symbols supports or maintains the others if vitally connected by the laws of association.

For the present, therefore, our conclusions must rest on imperial observation, and this leads us to the conclusion that the more we exercise the eye, ear, voice, and hand the more lasting the impression of a word will be. Each word has, so to speak, four roots, two sensory roots grounded in the visual and the auditory centers, and two motor roots grounded in the exercise of voice and hand. A word, therefore, with these four roots thoroughly developed will have a firmer hold in the memory-ground, if I may use this term, than one which has only one root.

Secondly, our observation also teaches us that, inasmuch as it is often uncertain as to which of the four processes a student may have most use for, the wisest thing to do is to give him a general training in all. A general elementary knowledge of reading, speaking and writing a language is as wise and as essential as a general education before a special training for a definite vocation. It would, indeed, be very helpful to our elementary instruction if some clever and careful investigator could give us, say, the 1,000 words in most common use. If this could be ascertained there would be little room for doubt as to what should constitute the material for our elementary instruction.

If, therefore, we are right in claiming that to know a language means ability to interpret and to use the auditory and the visual symbols, including in all four relatively distinct processes, viz., seeing, hearing, speaking and writing, then the pedagogical value of the Question and Answer as a method of Modern Language instruction is readily obvious. The question and answer, if rightly handled, will develop all four of these processes. For example:



It is plain from this diagram that a question which demands an immediate answer exercises only two of the language organs, viz., the ear and the voice, but dictation and recitation exercises them all.

The question and answer method, in our opinion, gives us at least a partial solution of the vexed and much discussed question, Can and ought the foreign language to be used in the class room? Of course it can and ought to be used. There are many other ways in which it can be used, but we are satisfied that the method under discussion is sound and can with profit be used by any teacher who is prepared to use it. There has been a lot of precious time and energy wasted by lecturing in the foreign tongue *over* the pupil, *under* the pupil and all *around* the pupil, but not *into* the pupil. The method we here advocate has the merit of giving the pupil *something*, and it can be used by a greater number of teachers, as they are at present prepared, than any other. I think we often expect too much of a few years of modern language work. We surely cannot hope to learn the whole language in that time, and yet if we propose to teach conversation people wonder why we can't turn out perfect linguists in a short time. The learning of only *one* language, that of our mother tongue, is a life work and can never be complete. How, then, is it possible to obtain in a few years a perfect command of several foreign tongues? But we can give the pupil a fair start in this direction. We can give him such a start in the elements of the language that he will find it comparatively easy to take up or continue a more specialized knowledge of the language if his vocation in life should demand it. This general training of all the fundamental language processes should, it seems to us, be steadily before the eye of the teacher who is dealing with students who are still getting a general education.

The text-books to be selected for this work should contain only the vocabulary in most general use, and should, in addition to grammatical principles and forms, contain easy texts in the language taught, together with and without questions. It will tend materially to enhance the interest of the class if the teacher formulates and dictates her own questions and requires her pupils to form questions which are answered and corrected in class. We have found it very useful, *e. g.*, to select for questions and answers, say, one page of the text used, ask the pupils to construct questions on this and have them become so familiar with this portion of the text that they can answer any questions based upon it. There is, of course, plenty of room here for the ingenuity of the teacher, but a few simple questions dictated by the teachers or formulated by the pupil each day on the text used will show very satisfactory results. These should be confined to the easier portion of the text which does not need to be translated; the more difficult portions should always be translated.

It is right here in connection with difficult passages that we are not yet clear as to how far the foreign language can and ought to be used. Our experience thus far leads us to the conclusion that in the interpretation of difficult passages which are often difficult of comprehension when couched in plain English, we are wasting valuable time in trying to give the explanation in the foreign tongue. I hope we shall hear from teachers who have tried to use exclusively the foreign tongue in teaching the classics.

The discussion of any method of instruction necessarily involves the consideration of the teacher's preparation, *for the teacher's preparation determines his method.* It is worse than useless to attempt to use a method for which the teacher is not prepared. And that is largely the case with the method that we are advocating in this paper. The teacher, to use this method with the greatest degree of success, should really handle the foreign tongue as readily as the foreigner himself. This would be ideal. But very much may be accomplished with a lesser degree of facility in the spoken language. Even the slightest acquaintance with the spoken language can be used to advantage. On the other hand the teacher who has been trained only in grammar, translation, written composition and old dialects will fail in the use of this method. A teacher thus trained is only half prepared, and, worse than that, she is wrongly prepared, because had she spent some of her time in trying to get the living language instead of the dead language she would be infinitely more efficient. Now I am going to make a heretical statement, although I am glad to say that in some institutions it is no longer regarded as heresy, viz., that if the teacher in getting her preparation in German had to choose between a knowledge of all the old dialects, Gothic, O. H. G., M. H. G., and Old Norse and even Indo-European, and one year's residence in Germany, she would be infinitely wiser to choose the latter. The ideally prepared teacher should have mastered at least one old dialect and have a general knowledge of the history of the language. Often hints can be drawn from this source which are very practical and develop interest. For example, the words der Buchstube, die Buche, das Buch can be impressed upon the memories of the pupils much more effectively if the teacher can tell them why they are so much alike in form and yet so different in meaning. In fact the teacher can unroll a veritable "Kulturbild" from these few words. This is true of many other words which the elementary students will understand without much knowledge of phonetic changes, and the teacher does not need much of this knowledge to give the necessary explanation.

The point we wish to emphasize is that the student who has to learn the foreign tongue should first be thoroughly grounded in the modern language before he takes up dialects the form of which resemble the modren forms so closely that he simply gets both confused.

The institutions which prepare the modern language teacher for her work are and always will be chiefly responsible for the way these languages are taught. In our opinion many of these institutions will have to modify their courses of study before they can hope to give the most practical a most efficient preparation to the teacher.

There has often been and still is too much emphasis on the old dialects before the student has sufficiently mastered the living language. For much of the written translations into the German, based on such a work as Harris' composition, more conversation and spontaneous exercises should be substituted. A certain amount of such translation work is essential to

the better understanding of the structure of the German sentence as compared with that of the English, but on the whole this kind of work has been much overestimated in giving the student a ready mastery of the language. Much valuable time of both pupil and teacher have actually been wasted.

The universities in addition to giving more oral and spontaneous composition should provide for courses of lectures given entirely in the foreign tongue. The German universities have long had their "Lector." Some such system ought to exist in every institution that claims to prepare students to teach modern languages. Residence abroad should be emphasized by lectures given on this subject informing students of the absolute necessity of such a course if they wish to be rightly prepared and advising them as to ways and means. The excellent opportunities offered by the best continental summer schools for those who cannot afford to be away a whole year, should receive special emphasis. Yes, it would not be too fanciful for the universities to suggest to its students that the time may come when residence abroad will be made a requirement, say for granting a life certificate in modern language.

To assist needy and worthy students travelling fellowships in modern language should be established. We need these fellowships infinitely more than the student of the classics. If it is deemed essential that the classical philologist should see a few original inscriptions carved on dead stone how much more important is it that the student of modern languages should feel the pulse of the warm, living blood as it bounds through the veins of a mighty people still a prominent factor in moulding the destiny of the world.

If the universities will emphasize these things the student will feel that he is not studying a dead language but a living language—a language representing a people that are, to say the least, still very much alive. I do not think that it is possible for any one who has not actually lived among the Germans for a considerable period of time to realize the tremendous energy of this nation. The classical period of German literature, using literature in its broadest sense, is perhaps the richest the world has ever seen, and yet this is but a part of Germany. The industrial position that Germany is gradually assuming among the nations of the world is perhaps of equal importance to the teacher of German. It is of this modern living Germany, with its hopes and ambitions, that we as teachers are often densely ignorant.

Wilhelm von Polenz, in his recent work on America, entitled "Das Land der Zukunft," says: "Es gibt nicht zwei Völker auf dem ganzen Erdenrund, die so viel von einander lernen Könnten, wie das Amerikanische und das deutsche, und es gibt keine zwei Völker, die vorläufig sich so wenig im innersten Kern ihres Wesens verstehen, wie grade diese beiden."

This view is shared by other scholars who have really studied this question.

A most interesting report has recently been published on this subject by the "Department of Commerce and Labor" at Washington, D. C. It is entitled, "Industrial Education and Industrial Conditions in Germany."

This work should be read by every teacher of German. It can be secured free by sending to the department for it. This study shows how Germany is very liable to surpass us in our own boasted field, viz., industry. They have industrial schools to prepare for every specialized industrial trade. But we cannot go into details. We cannot, however, refrain from citing a few sentences (p. 149): "As we extend our export trade the men we meet and the wares with which we have to compete are German. While England is feeling the force of the German Empire's facilities in securing trade at present, we are not to be exempted. No competitor with whom we will have to deal is so well prepared for success in the world's markets as is Germany."

In the "Daily Consular Report" of Jan. 27, 1905, issued by the same department, we find a report of the impression of America as carried back to Germany by a German commission appointed to visit the St. Louis Exposition and incidentally to study industrial conditions in different parts of our own country. Among other things Mr. Mason, U. S. Consul-General at Berlin, who sums up these impressions of our country as given out in Germany, says: "There has been noticed, to begin with, on the part of our people, a general feeling of complacent satisfaction with everything American, a secure conviction that whatever is done or produced by them is the best, and that they have only to keep on as they have begun to have the future securely in their hands. There is, say these critics, a pervading ignorance and indifference about everything outside of the United States that, from the German standpoint, will be, unless corrected, a serious handicap in our quest for foreign trade. The careless confidence with which agents and salesmen are sent abroad, with no special preparation and with no knowledge of any language but their own to do business in countries where only a trifling percentage of the population understand English, strikes these careful, methodical European experts as amazing." * * * Reduced to its simplest terms, these investigators generally conclude that the reliance on a general and more or less superficial education, together with natural adaptability, to fit young men for almost every walk in life, and the lack of specialized study in physical science, modern languages, and the industrial arts, will, if persisted in, neutralize much of the advantage which our country enjoys through natural resources and advantageous geographical position for the South American, Mexican, and Asiatic trade. They note, also, the enormous disparity between American and European wages, the high rates charged by express companies, and the general heavy cost of handling business in the United States, and conclude that on the whole the "American danger" has been greatly exaggerated, and that a steadfast adherence by Germany to the educational system and commercial methods now in practice will leave the Fatherland little to fear in future competition with American manufactured goods."

Now some one may say what has all this got to do with my subject for discussion. It has everything to do with it. The question and answer method breathes and fosters the living spirit of the language and leads

naturally to the living Germany. We should never lose sight of the supreme function of the modern language teacher which is to stand as mediator between our civilization and the civilization of the foreign nation his language represents. This function of the teacher receives additional emphasis in recent theories of social progress. Such men as Tarde in France, Balwin in America, and the representatives of the "Völkerpsychologie" in Germany have shown that progress in civilization depends largely on the conditions which make possible "intercerebral" activity, *i. e.*, interchange of ideas between individuals. Isolated man makes little or no progress. Civilization is chiefly the product of the interaction of social forces, and it is the foreign forces that the modern language teacher should try to connect with our own and thus make possible the highest development of our own people.

Synopsis of Business Meeting

UNIVERSITY HALL, April 1, 1905.

The meeting was called to order by President J. L. Snyder. The minutes were read by the Secretary, L. P. Jocelyn. Reports were made by the Secretary, Treasurer J. P. Everett, and Chairman of the Auditing Committee, J. L. Markley. The reports were adopted.

SYNOPSIS OF TREASURER'S REPORT.

Balance last reported	$ 30 69
Receipts	508 00
Total	$538 69
Disbursements	415 53
March 22, 1905—Balance on hand	$123 16

The chief items of expense are (1) printing the proceedings, (2) printing 3,000 programs and mailing them, and (3) the expense of the speakers at the general meetings.

The nominating committee consisted of H. M. Slauson, N. T. Bishop, N. G. Cobern, S. O. Hartwell and L. P. Jocelyn. They made the following report, which was adopted:

For President—Professor A. S. Whitney, University.
For Vice-President—Miss Edith E. Atkins, Lansing.
For Treasurer—Principal J. P. Everett, Adrian.
(The Secretaryship is permanent.)
For the Executive Committee, the above officers and
President L. H. Jones, Normal College.
Principal T. P. Hickey, Battle Creek.
Upon motion of B. A. Finney, the chair appointed
Mr. B. A. Finney, University Library,
Superintendent R. S. Garwood, Marshall,
Miss Mildred Smith, Ypsilanti,
as a committee to investigate the condition and resources of the high school libraries of the State, and report at the next meeting of the Club.

The Secretary called attention to the great growth of the Club and the need of a new Constitution and a new set of By-Laws, to assist the officers to properly manage all phases of the Club, and suggested that a committee be appointed for such purpose.

Upon motion of C. F. Adams, Detroit, the chair appointed as such committee:

J. O. Reed, University.
E. L. Lyman, Normal College.
David Mackenzie, Detroit.
J. L. Drake, University.
L. P. Jocelyn, Ann Arbor.

Upon motion of the Secretary, the Executive Committee were given power to change the days of meeting to Wednesday, Thursday and Friday.

Superintendent S. O. Hartwell gave the report of the Committee on High School Athletics, and it was adopted. (The report is printed in full on pages 10–13.)

Principal A. J. Volland, Grand Rapids, was elected to succeed himself for a period of five years as member of the State Athletic Committee.

Superintendent L. L. Wright, Ironwood, was elected to fill the unexpired term of L. H. Baker as member of the State Athletic Committee.

Program of the General Sessions and Conferences

FRIDAY.

1. The Nature of Culture Studies,
   Professor R. M. Wenley, University of Michigan.
2. The School of the Future,
   Professor Liberty H. Bailey, Cornell University.
3. Music,
   University School of Music Quartet.
4. Work in a Psychological Laboratory,
   Professor James R. Angell, University of Chicago.

Musical Recital,
   Faculty of the University School of Music.

Address—The University and the Nation,
   President Woodrow Wilson, Princeton University.

SATURDAY.

1. The School and the Library,
   Mr. W. H. Brett, Librarian Cleveland Public Library.
   Discussion:
   1. Mr. H. O. Severance, University of Michigan Library.
   2. Superintendent H. M. Slauson, Ann Arbor.
2. The Greek in English,
   Mr. Edwin L. Miller, Englewood High School, Chicago.
3. Music,
   University School of Music Quartet.
4. Business Meeting.
5. Athletics in Michigan Secondary Schools,
   Superintendent S. O. Hartwell, Kalamazoo

CLASSICAL CONFERENCE.

THURSDAY.

1. In the Footsteps of Caesar in Gaul: Gergovia,*
   Principal George R. Swain, Bay City High School.
2. Ten Classical Conferences: A Retrospect,
   Professor Francis W. Kelsey, University of Michigan.
3. Do Latin and Greek need something done for them in the schools?
   Principal J. Remsen Bishop, Eastern High School, Detroit.
4. Roman Brickstamps: Their Form, Significance and Value,
   Principal Irving B. Hunter, West Bay City High School.
5. Some Roman Brickstamps from the Collection of the University of Michigan,
   Mr. Henry M. Gelston, Bay City High School.
6. Some Poetic Uses of Geographical Expressions in Latin,
   Professor C. F. Ross, Allegheny College.
7. Pompeian Wall Scribblings,
   Miss Louise M. Breitenbach, Liggett School, Detroit.
8. The Municipal Senate in the African Provinces,
   Dr. T. L. Comparette, Hicksville, Ohio.
9. Attitude of Hadrian toward Inscriptions upon Buildings restored by him,
   Dr. Duane Reed Stuart, University of Michigan.
10. The Value of a Year in Italy for the Training of a Latin Teacher,
    Miss Fannie E. Sabin, State Normal School, De Kalb, Illinois.
11. The Social Structure of Gaul in the Time of Caesar,
    Principal Ira A. Beddow, Olivet College.
12. Effect of Physiographic Features upon the Movement of Population,*
    Professor C. H. VanTyne, University of Michigan.
13. The Title "Praetoria" in the Roman Navy,
    Mr. Orlando O. Norris, State Normal College, Ypsilanti.
14. Some Points in the Literary Study of Virgil,
    Professor Charles Knapp, Columbia University.

Address—The Lost Parts of Latin Literature,
Professor Andrew F. West, Princeton University.

FRIDAY.

15. The Latest Excavations in the Roman Forum,
    Professor Walter Dennison, University of Michigan.
16. Palaeographical Miscellany,
    Professor John M. Burnam, University of Cincinnati.
17. The Eleusinian Mysteries,*
    Professor Arthur Fairbanks, University of Iowa.
18. The Ara Pacis of Augustus, and Its Restoration,*
    Professor James C. Egbert, Columbia University.

*Illustrated with the stereopticon.

JOINT SESSION OF THE CLASSICAL AND MODERN LANGUAGE CONFERENCES.

THURSDAY.

The Remains of Ancient Greek Music, and an experiment with Latin metres,
Professor W. H. Wait, University of Michigan, and Miss Leila Farlin, University School of Music.

Address—Prevailing Methods in the Study of Mood-Syntax in the Indo-European Languages: Their History and Their Aim,
Professor William Gardner Hale, University of Chicago.

CONFERENCE OF PHYSICS AND CHEMISTRY.

THURSDAY.

1. Report of Committee—A Proposed List of Experiments for Beginning Chemistry.
2. What Should be Taught in Beginning Chemistry?
   Professor F. S. Kedzie, Michigan Agricultural College.
3. The Chemistry Note Book,
   Mr. E. J. Wilson, Adrian.
4. Quantitative Determination of the Strength of an Acid by Means of a Weighed Amount of Sodium,
   Mr. M. A. Cobb, Lansing.
5. Analysis of Nitric Acid,
   Mr. B. W. Peet, Michigan State Normal College.
6. The Determination of the Per Cent of Carbon Dioxide in Calcium Carbonate,
   Mr. J. W. Matthews, Western High School, Detroit.
7. Quantitative Relation between Acids, Bases and Salts: the Preparation of Primary and Secondary Salts of Sulphuric Acid,
   Mr. R. R. Putnam, Eastern High School, Detroit.
8. The Volumetric Synthesis of Water,
   Professor G. A. Hulett, University of Michigan.
9. A Simple Experiment to Determine the Volumetric Composition of Ammonia.
   Mr. L. S. Parmelee, Flint.

FRIDAY.

1. A Contact Key for the Slide-Wire Bridge,
   Mr. H. L. Curtis, Michigan Agricultural College.
2. A Simple Resonator,
   Mr. M. A. Cobb, Lansing.
3. A Simple Means of Illustrating the Principle of Step-up and Step-down Devices,
   Mr. De Forrest Ross, Ypsilanti.

4. An Account of Experiments to Ascertain Whether the Human Organism Obeys the Principle of the Conservation of Energy,
   Dr. Arthur W. Smith, University of Michigan.
5. A Wireless Telegraph Outfit,
   Superintendent J. J. Marshall, Romeo.
6. Melde's Apparatus for Boyle's Law,
   Mr. C. S. Cooke, Central High School, Detroit.
7. Coefficient of Expansion of Air Under Constant Pressure,
   Mr. E. A. Clemans, Central High School, Detroit.

SATURDAY.

1. Report of the Committee on Mathematics and Physics,
   Mr. Charles W. Burrows, Central High School, Detroit.
2. Some New Apparatus for Experiments in Vibratory Motion,
   Professor John O. Reed, University of Michigan.
3. The Algebraic Equations of Lissajous' Curves,
   Professor G. E. Marsh, Case School of Applied Science, Cleveland, Ohio.
4. Density Measurement by the Manometer; Pressure Measurement by the Manometer,
   Professor F. L. Keeler, Central State Normal School.
5. A Device for Releasing the Ball upon the Inclined Plane,
   Mr. V. R. Hungerford, Decatur.
6. An Apparatus for Illustrating the Equality of Expansion of Different Cases.
   Mr. C. F. Adams, Central High School, Detroit.
7. An Electric Pendulum for Laboratory Use,
   Mr. W. H. Hawkes, Ann Arbor.

JOINT MEETING BIOLOGICAL CONFERENCE AND SCIENCE TEACHING.

FRIDAY.

A FIELD STUDY SYMPOSIUM.

1. Elementary Field Work; Aims and Methods,
   I. B. Meyers, School of Education, University of Chicago.
   Discussion opened by Professor L. H. Bailey, Cornell University.
2. Aims and Methods of Physiographic Field Work in Secondary Schools,
   Professor M. S. W. Jefferson, State Normal College.
   Discussion opened by Professor R. D. Calkins, Central Normal School.
3. Aims and Methods of Zoölogical Field Work in Secondary Schools,
   Curator C. E. Adams, University of Michigan.
   Discussion opened by Miss Jessie Phelps, State Normal College.

4. Aims and Methods of Botanical Field Work in Secondary Schools. Illustrated with lantern.
   Dr. H. C. Cowles, University of Chicago.
   Discussion opened by E. N. Moseley, Sandusky High School.
5. Field Work in Botany for the Winter Season,
   J. Harlan Bretz, Albion College.

MATHEMATICAL CONFERENCE.

FRIDAY.

1. The Use of Graphs and Graphic Methods,
   Miss Sadie M. Alley, Western High School, Detroit.
2. Non-Euclidean Geometry,
   Dr. Louis C. Karpinski, University of Michigan.
3. Certain Aspects of the Present Teaching of Secondary Mathematics,
   Mr. Claude I. Palmer, Armour Institute, Chicago, Ill.

ENGLISH CONFERENCE.

FRIDAY.

No formal papers were presented, but teachers of English Composition and Literature were invited to come together for presentation of difficulties and for free conference on methods and aims in coördinating and conducting the various branches of the work.

HISTORY CONFERENCE.

FRIDAY.

1. The Motive of the French Alliance in the American Revolution,
   Professor C. H. VanTyne, University of Michigan.
2. Principal Weaknesses Shown by Students in the Introductory Work in History at the University, with some Consideration of a Remedy.
   Professor Earle W. Dow, University of Michigan.
3. Use of Stereopticon in the Teaching of History, Illustrated with the Lantern,
   Professor C. H. VanTyne, University of Michigan.

MODERN LANGUAGE CONFERENCE.

THURSDAY.

1. Through the William Tell Country,
   Miss Anna M. Barnard, Central State Normal School.
2. Recent French Poetry,
   Professor Arthur G. Canfield, University of Michigan.

3. Composition of the Nibelungenlied,
   Dr. Ida Fleischer, Michigan State Normal College.
4. The Dramas of Gustav Freytag,
   Professor J. A. C. Hildner, University of Michigan.

GERMAN CONFERENCE.

FRIDAY.

1. The Essentials of German Composition,
   Miss Alice E. Rothmann, Ann Arbor High School.
2. Should the Study of the German Classics be taken up in our High Schools?
   Professor Johannes Zedler, Albion College.
3. Some Methods of Arousing Interest in the Class Room,
   Miss Alice Maud Pound, Western High School, Detroit.
4. The Question and Answer in Modern Language Instruction. Its Import and Pedagogical Value.
   Professor John E. Lautner, Northern State Normal School.

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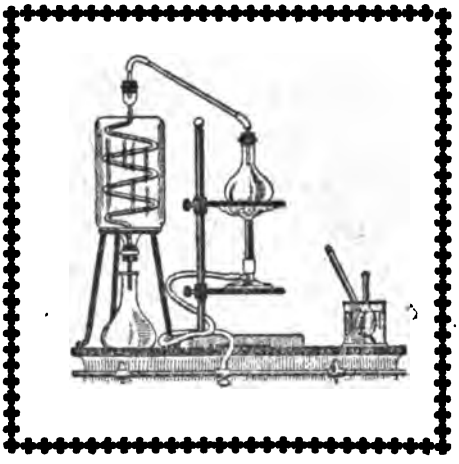

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OF THE

Michigan Schoolmasters' Club

AT THE

Forty-First Meeting

HELD IN

ANN ARBOR, March 29, 30, 31,

1906

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PROCEEDINGS

OF THE

MICHIGAN SCHOOLMASTERS' CLUB

FORTY-FIRST MEETING

HELD IN ANN ARBOR, MARCH 29, 30, 31, 1906

ANN ARBOR, MICHIGAN
PUBLISHED BY THE CLUB

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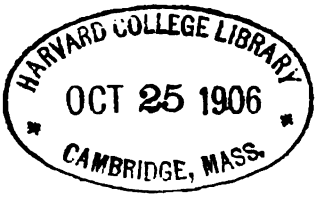

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Michigan Schoolmasters' Club

PROCEEDINGS OF THE FORTY-FIRST MEETING, HELD AT ANN ARBOR, MARCH 29, 30, 31, 1906

EDITED BY THE SECRETARY

GENERAL MEETINGS

The forty-first meeting of the Michigan Schoolmasters' Club began on Thursday, March 29, with meetings of the classical, modern language, and physics and chemistry conferences. The general meetings were held on Friday and Saturday mornings in University Hall. Friday morning Professor John T. McManis, of the Western Normal School, read a paper on "The Educational Import of Modern Thought." Dr. Theodore de Laguna, of the university, was unable to give his paper on account of illness, but it was read by Professor George Rebec, of the university. The title of Mr. de Laguna's paper was "Evolution and Moral Education." President E. G. Lancaster, of Olivet College, read a paper entitled "The Nature of the Child." These three papers are published in this number of the proceedings.

On Friday afternoon at four o'clock President W. O. Thompson, of the Ohio State University, was to have given an address upon "The Meaning of Education," but was unable to do so on account of the severe illness of the governor of Ohio.

At five o'clock in the Barbour gymnasium the members of the club attended a basketball game and a gymnastic drill given by the young ladies of the university; and at 8 o'clock they listened to a concert given by Sousa and his band. Persons holding membership tickets were admitted free to these entertainments.

On Saturday morning Mr. Jesse Davis, of Detroit, read a paper upon "Over-pressure in High Schools," which showed that there is no over-pressure in the high schools whose work he had investigated.

Professor John Dewey, of Columbia University, gave an address upon "Self Activity in Education; Its Meaning and Conditions."

On Thursday evening at the close of the joint session of the classical and modern language conferences, an informal reception was held in the parlors of the Barbour gymnasium to enable teachers to meet the speakers, the officers of the club and the members of the Faculty of the University in the departments of Ancient and Modern Languages.

The program of the general meetings and of the different conferences of the club is given in full on page ——

The minutes of the business meeting and the new articles of association and by-laws may be found immediately following the papers.

THE EDUCATIONAL IMPORT OF MODERN THOUGHT

PROFESSOR JOHN T. MC MANIS, WESTERN NORMAL.

There is nothing more striking to even the casual observer of modern life than the machinery of industrial and business activities. Within the last forty or fifty years every line of industry has built up its own particular system. Moreover, the complications of these systems has grown so great that it takes a lifetime to master them, the consequence being that their effectiveness is greatly reduced, and the management of them is accompanied with enormous waste. But, extravagance is only a natural result of an effort to systematize on a large scale the output of industry. As it is now, every change in style of living or method of finishing products leaves the useless and surplus remnants to be thrown aside to make room for new installments.

Within the realm of the various distinctively social institutions, one also finds evidence of wheels and levers and pulleys. Again one finds here that each department has its system. Just as in the industrial world there is little hope for the individual outside the limits of the corporations, so with social institutions, there is small chance for independent activity. Even in this twentieth century, with its rapid strides in freedom of thought and action, our beliefs are still so largely pinned to organization, to prevailing custom, that we can scarcely tolerate the *independent,* and we tend to look with suspicion or commiseration on the one who refuses to co-operate with the powers that be.

The educational system is bound up in this same set of forces. For the most part, it is machinery that moves the schools. Systematization and organization are the pre-requisites for a modicum of success in every educational effort. The school that is not controlled by a system is of necessity regarded as inefficient in its cultural influence. Before the institution can begin to work, it must be completely supplied with costly equipment and large endowment. Its patronage of wealth and its dependence on advertisement are systems, refined beyond the ken of the ordinary individual. School-room practice is tied up in the interminable complexity of this system. The subjects to be taught, the pages to be covered, the exact time limits for recitations, the plans and devices, all these fit into the whole like cogs, and turn in their exact order in the great machine. The concern is oiled, not always by professionally prepared lubricants, but, too often, by the greasy dope of political ethics.

Thus it is that the Siren's voice in modern America is not the beckoning of some far-off, shadowy unreality, or vague ideal, luring on to high endeavor, but, is rather the rattle and bang of the business

machine, the buzz and grind of wheels, the screech of the twentieth century limited, or the loud sounding notoriety in the struggle for advertisement. The reduction of everything to a beautifully working system and an exact order, forms the controlling passion of men in every walk of life. The modern utilitarian mind abhors chaos as nature does a vacuum.

However, there is no reason for assuming that this passion is the only or final and dominating force in the modern world. Its sway is not so complete as might be judged from what I have said, for if it were, there would be slight need for our efforts at improvement. The tendency in the direction of building up organizations is symptomatic of forces of more vital import than is shown on the surface of things. No one doubts that the reduction of the various phases of life to complete order and system, leaves still the largest part of the whole unresolved. We are still face to face with the problem that living is the business of life, for which, systems and organizations form only the tools. One needs must listen more sharply to catch the meaning of this chaotic order and hubbub.

In his efforts to detect this meaning, the observer is struck with the fact that these confused attempts at organization and sysematization point consistently to certain more or less clearly defined pre-suppositions which form the controlling concepts of modern life. It is with these concepts and their bearing upon the educational practice in the elementary schools that I am concerned. What I shall say on the theoretical side is more or less common opinion among those who make any pretense to thought, and, consequently, it is not on this side that my contribution is offered; but, I am rather interested in the bearing that some of these most commonly accepted ideas have upon school work, knowing full well, that, however glibly we speak of these things in books and educational conventions, there is still a wide divergence between them and the actual teaching process. Not that, of course, we are not making progress in control and intelligence, but that there is much that remains to be done in the school room, in order to bring these to a higher plane.

Of these pre-suppositions there are only two that I shall have time to discuss, however desirable it might be to go into detail in many other directions. Moreover, the educational relationships I have in mind to make must necessarily be brief, and yet, I hope their bearing may be typical of many other principles. These two pre-suppositions are the underlying and basic elements in democracy and science, and should, therefore, have a significant place in all educational procedure.

In the first place, then, and deeper than the American's faith in his machinery, lies his over-weening confidence in himself and his capacity to do that whereunto he has set his hand. At once, it is clear that it is out of just this belief in himself that the machinery and

organization spring, for the latter are in fact but the lengthening of his own reach. His faith in self is not second to that in his system, and this naive and often undefined appreciation of his own power usually grows in proportion as his perspective of life and history narrows. Even though the individual may fall victim to the creations of his hands and brain, he blames circumstances and not himself.

From such a feeling of his own significance in the order of things, man brings upon himself the conflict, which is present in all stages and phases of civilization, between his private demands and the general institutional organizations, and which we are even now facing in some of its most acute forms. From this same feeling of the worth of man and his activities, there arises, too, the salvation of the individual from the ultimate domination of the shackles of institutionalism. Man knows himself greater than the work of his own hands, and knows, too, that when it is necessary, he can set himself against these and destroy them. He can refuse to be crushed by the machines he has builded, and, though it may take time, even those institutions, hoary with sacred traditions, may fall beneath his iconoclastic energy. The common man does not long hesitate, when the need is his own hearth to use the accumulations of the ages for firewood. Between the inherited expressions of the processes of life, made uniform by the struggle of ages, and the variations in individual conditions and demands, there is always this friction and need of reorganization. History is a record of the periodic return to valuations defined in terms of human personality; and this is what makes it true that the content of our concepts of worth must finally consist in the sweat and blood of mankind.

This faith in the ultimate worth of the individual finds its highest expression in democracy. Consequently, it is true that, while on the face of affairs we seem to be dominated by organization, after all, the belief in the integrity and significance of the individual lies deeper and farther back than the system. But, as yet, we have not been willing to carry out into many fields the logical implications of democracy. The full meaning of the term is not possible of apprehension till each aspect of the maze of experience is given the same chance as any other to demonstrate its worth to the whole. If this attitude were taken toward democracy, each avenue of life would have applied to it those standards which are now significant in but few phases of activity. However, it must not be supposed that the development of the full worth of the individual through democracy carries with it an inevitable destruction of the institutional organizations. On the contrary, these institutions are only thus given their proper place as means of interpreting man to himself and of carrying into effect his needs and motives. Institutions in this way, become not ultimate ends to be attained, but methods by which each succeeding generation attains a more economical and efficient form for dealing with its problems of

life. Democracy in its last analysis consists in giving to each one the largest possible control of his activities in light of the common inheritance of mankind. Moreover, the attainment of an efficient democratic organization is possible only through a firm faith in the ultimate significance of the individual activities and thoughts as the goal of humanity.

One finds himself beset by many startling obstacles when he undertakes to discover this faith in the integrity of the demands of children in the schools, and he is shortly convinced that the most palpable fact about it is its absence. The treatment of youth in elementary school practice does not follow this commonplace of modern thought. The emphasis falls upon mere uniformity in the classification and teaching of pupils in the lower grades. School furniture and apparatus, uniform desks and seats, books and supplies, are all made upon the assumption of unvarying likeness in the processes of learning and attainment of results. The monotony of a dead level controls the assignment of lessons and the recitation from the common page, with equal emphasis on all points for all individuals. These regulations are only the merest excuse for democracy and are based on a complete misconception of the problem. The schoolroom is not now in a position to allow each individual to be determined in his activity in terms of what he can contribute to the common product of his own group. In its most vital sense this emphasis upon uniformity is the most insidious agency in destroying that faith in the power of the individual pupil to initiate and control his own attitude with reference to the most fundamental principles of society, which is, after all, the highest meaning of democracy. But again, we have our conflict between the general social demands and the personal needs; and so long as we persist in either disregarding one or the other, or, in arbitrarily setting them over against each other from an external point of view; and so long as we fail to recognize and employ in schoolroom practice the unity in the fundamental processes of human life and endeavor on the one hand, and the natural and vital variations of individuals on the other, just so long must our control present this wavering back and forth between anarchy and absolute sway of mere authority.

But, I am told, the schools are already organized upon the basis of just this recognition of democratic principles. In answer, I would say, in the first place, that there is a growing appreciation in the schoolroom of this point of view, and that the bright spots in our country where this is practiced are increasing in number; but, in the second place, such spots stand out because of their rareness as the work of choice teaching spirits. Further than this, the rank and file of our common schools are not proceeding upon such a basis, and, in many cases, intelligent and conscientious teachers are prevented from doing so on account of the effectiveness of the machinery of organiza-

tion and supervision. Simply because a school has manual training or nature study and other modern facilities in its curriculum is no prima facie evidence that the actual work has been organized under new concepts and is being carried on with a full appreciation of the meaning of these subjects. On the other hand, I may be accused of advocating rank individualism in the treatment of children, but it need only be recalled that I have thrown my emphasis for the determination of the conduct of the individual upon the general social body of which he constitutes an active and participating factor, to see that this fear is groundless.

If space permitted, I should like to show that these principles are true, not only for the pupils of the schools, but, in the same imperative sense, for those who teach these pupils. The teacher has the same right to demand that her relation to the whole be determined by the vital principles of democracy as any other individual, and where this is not recognized she must continue to give only partial obedience to the organization to which she is bound by superficial considerations. Our normal schools still continue to inculcate this superficial conformity to prescribed and empirical practice, the pattern for which is set without reference to a grasp of the controlling concepts in the situation.

But, alongside the faith in the ultimate worth of the individual stands a second as significant assumption as that of democracy, viz., a faith in the realness of the things which man handles and his method of dealing with them. This forms the second of the pre-suppositions toward which modern organizational activity points, which I wish to discuss in relation to educational practice. It is not merely a belief in the worth of the individual which characterizes our American thought, even though this forms one of the strongest factors in our civilization; but a like valuation and prize is set upon the things with which man comes in contact. The reality of the facts which answer the demands of his organism is unquestioned. In spite of the idealistic tendnecies of the present, there is prevalent a naturalistic attitude and naive acceptance of things and forces as they seem to be and as they can be used in the practical activities and purposes of life. The scientist and man of affairs both take facts for granted and build their world accordingly. Science is only possible on this assumption, for in no other way could the things one handles and investigates and uses have significance or mean anything to human activity. Faith in the validity of the processes of experience as ultimate tests of reality, forms, therefore, a fundamental postulate of modern thought; and the individual who throws over his reliance upon empirical standards and methods renders himself impotent to interpret the meanings of this thought.

Granting the commonplace of this statement in provinces where original investigations are carried on and where constructive activities

are encouraged, there still remains the field of early education, the common schools, where it has no such acceptance. The controlling practice of elementary education continues to be that, opposed by men like Rousseau and Froebel, of a prescriptive and external sort, and not that founded on the principles of modern science. The interests of the child and his capability of judging values for himself and others are persistently disregarded. The result is that the material must all be given the child, and habits must first be fastened on him by an external application, before he is able to become self-active. Locke went over this ground very thoroughly from his John Bull's point of view long ago, and his treatment would have satisfied conditions, providing child mind began life as an "empty cabinet" to be filled. But, since it is true that life begins with a decidedly complex organism to be satisfied through action and reaction, this formulation is far too simple to be adequate in the concrete. Every step in the satisfaction of the demand for experience on the part of the organism is by the nature of the case a balancing and testing of forces, and consequently must go on in the form of more or less hazardous experimentation. The child life from the start manifests the hunger and energy requisite to the demands of larger or smaller proportion, as age advances; and these manifestations present the same method that life has always used and that the scientist now uses in the investigation of his problems. This is not a contention for an education which employs the same slow process as that used by the race. Without doubt, we are able to take advantage of many things accomplished by civilization and make much more rapid development than ever before; but the disregard of the method by which these steps have been made must bring failure to our efforts to produce sane and strong character. The birthright of every man is this primitive and immediate struggle with the elemental factors that have formed the race, and the same sort of appreciations and intellectual valuations that have arisen from direct contact with the situations typical of his own stage of growth. Moreover, it is out of his experience in such a contact as this that there must grow the structure of civilizaiton, which too often we have attempted to impose *ab extra*.

Again I must repeat, that however much there may be of the commonplace in this proposition as a topic of educational or scientific discussion, there is far from common, or even limited, acceptance or recognition of it in the schools. I am confronted almost daily with the fact that in common practice the child's efforts and processes and evaluations are discredited, and for them are substituted, by a kind of artificial grafting, objective and foreign interests and methods. Faith in the power of the child to find and know reality, when he is placed in the presence of social and personal demands and needs, is too generally wanting. It is in the school that there is need of the appreciation of the fact that the mere acquisition of material, no matter how

scientifically arranged, can never take the place of a live experience with people and things and the resolution of this experience in terms of the child's own history. After all, it must fall to the teacher to bring the child to an appreciation of his responsibility for intelligent participation in the social functions.

If we accept this statement, then, that education of any importance must finally rest back on experience of an elemental and direct type, it follows that we must utilize as many of the various demands of child nature as possible within the limitations of the school. The earlier we utilize the initiative and self-dependence of the child the sooner there is given stability to the whole experience process, for he cannot proceed without organizing what he has already attained. The presentation of concrete situations that require the reorganization of what is learned will relieve us of the educational practice which makes its principal aim the inculcation of facts bearing no direct relation to the child's experience. The utilization of the demands of experience would change the character of the work, e. g., in geography, by giving them an organic connection to the life of the individual. The complaints which we all make of the poor preparatory work of students coming from the lower schools would cease if we could once realize in our practice that education is a more vital process than merely imparting information; that the human organism is an active, appreciative structure, builded on the same plan and seeking the same ends in large measure that the race has sought; and, therefore, having a method and integrity that can be relied on to reach worthy results.

But we are told that the school cannot take into consideration the entire scope of the child's experience, that the school has always been compelled to limit itself to particular and specialized forms of activity. Even though the life of the individual in a larger sense is the true educational material, yet, according to tradition, the school must necessarily leave aside the loves and hates, the ambitions and appreciations, the labors directed to practical needs, and the contacts with larger and fuller reality as things outside its realm. We are made to believe that the school can take only those values for its function which have already been established by rationalistic or reflective activity. In spite of the fact that there are other and different forms of experience of as great importance as merely the intellectual kind, these have been and are persistently disregarded. The attitude of the child, the appreciation, the moral sense, the motor skill, and the sympathetic insight, while they cannot be taken account of in terms of percentages on examinations, are still the very heart of the meaning of life. A scientific treatment of these different forms demands that they shall be given full credit for their own peculiar contributions to the significant reality of the normal human being.

Now, if we recognize that there are these many modes of experiencing, and that they are alike worthy and carry with them their own

values, even though the school has not hitherto provided for them in its formal plans, it is all the more imperative, if we are expecting to advance our work, that we should consider them as legitimate phases of the educational function. Although every age may be thought in some respect a transitional one, there never was a time when we were in greater need of making new definitions of education than the present, and of enlarging its scope so as to take into account the entire social context of child life.

From this point of view the fundamental problem now comes to be how to construct from these varied forms of experience, types or units of valuation that can be used in a practical way in teaching. In light of these units the teacher can measure with some assurance values that cannot now be estimated because our only standards are intellectual ones. It should be possible to estimate the pleasure—pain—arising from a given procedure, the degree of manual skill coming from specific work, or the practical utility in given exercises in terms of their relation to the larger fields to which they lead.

In the development of educational units for the measurement of these various forms of experience, it is necessary, in the first place, to get rid of some ideas that have clogged the teaching process for centuries. It should be made clear at once that it is not possible to make one form of experience stand wholly for the work of other forms. If the play of children is educative it is not merely educative in terms of arithmetic, nor can the educational value of manual training be given in terms of Latin composition. The norm or standard of reality in one line of conduct cannot be generalized into a norm for all other forms of conduct, for in every case it is necessary to take into consideration the historic context out of which and for which this norm arose. Our principal difficulty has come over and over again in trying to make one subject stand as the test for the value of other subjects; just as, in many places, arithmetic has been the touchstone by which both students and subjects have been compelled to yield all their possibilities to the magic power of this convenient instrument. But the impotence of a standard of mathematics in measuring qualities of energy and ambition, likes or dislikes, and personal interests, has been proven in practically every field of educational activity.

Again, in the formation of norms or standards by which to estimate the educational value of the different forms of experience, it is necessary that we proceed upon lines laid down by science and common sense. A thing shall be estimated in so far as possible for what it is itself worth, and worth, in turn, takes into consideration the complete social scale of activities, and not some limited phase of these. More than anything else in educational thought, we are in need of a procedure that gives definite and positive concepts of educational values. We are overburdened with educational opinions, and we need simple, direct and constructive standards, tested by the laboratory from data

found in actual conditions. Moreover, until there is applied to common school activity some form of scientific estimate and accurate measurement in a large and comprehensive way, the educational thought and procedure will be dependent upon these assertive formulations. In place of mere opinion and political or religious prejudice as guides, education needs carefully organized and developed concepts. Our normal schools and university departments of education must stand more as laboratories for the investigation of these problems in school practice, and for the collaboration of the results of these investigations on a large and usable scale, rather than for the doling out of classroom-made theories and artificial practice-school technique. We need to be able to show in a practical and definite way that manual training has, or has not, a specific value, that writing has a peculiar place, and so on through the list, and that each one of these values belongs to the subject, considered in the light of its relation to the total experience of the individual. The child that gains experience through æsthetic appreciation, or through constructive motor sources, deserves as careful and accurate treatment as any other, for he may have as vital hold on reality as the child with a precocious intellectual grasp on details. All ways of reaching reality are equally true ways, and we need to be able to judge the value of these accurately. Art, nature study, industrial activity, are to be estimated by their power to bring the child into sympathetic and constructive relation with the whole life of which he forms a part. Strange as it may seem, we have not been willing to grant the worth for formal educational activity to such a thing as the plain ordinary *use* in a given piece of work, or the happy and radiant satisfaction coming from another. Eighteenth centuryism, of the sort John Stuart Mill was given, discounts every phase of experience which cannot be developed as note-book pabulum or examination facts, and this same spirit is to be seen today in many different forms throughout our school system.

The selection of norms for the significant modes of experience means, among other things, that we are determining the content of the course of study. Whatever else this may contain, it should cover, as our best courses do today, the possible typical forms of experience. The difficulty is not so much in selecting the material for a curriculum, as it is in opening up avenues in this for different individuals and holding each responsible for the truth and meaning he is able to reach through it. In general, two principles can be derived from the point of view we have taken which help in the choice of subject-matter for the curriculum. The first of these involves the *immediate* experience value of educative material to the child in his contact with it. We cannot expect the subject to have much weight with the child if its value is pushed too far into the future, for it thus loses its immediate meaning to the organism and has no application to the present need. This has too often been the difficulty with our courses of study, for

they took for granted the fact that education was wholly a preparation for adult life, and there was no need that it should have any significant value to the child, as a child. In emphasizing the immediate use to the individual of any given material, we are not overlooking the fact that this use is determined by his social relations, a consideration necessary to give consistency to the course. The second principle involves the historic aspect of the child's life. The material of instruction is determined by the child's place in terms of the race development and his own degree of individual advancement in the scale of growth. On the basis of this principle, every phase of educational material and activity looks toward a larger and more complete future of experience, and a more intelligent control of this experience than that given by the mere satisfaction of the immediate end. It is impossible to go into the full bearing of this selection of subject-matter at this point; and, it must therefore, suffice to say in summary, that the material should possess the greatest flexibility, and the details should be left to the individual needs and variations, although the main trend must be fixed by more comprehensive social demands.

The course of study and educational practice as determined on these principles furnish the possibility of experience in many forms. It is not necessary to live on bread alone, when the world is full of sunshine and air and water and other equally useful things. Likewise, it is not necessary to live on realities of intellectual formulation alone, when there are other worlds of significant reality about us. Reflective and rational nutrition gets its value for the organism in an indirect way at best, and, therefore, must be administered only as the system has taken more organic and substantial foods, those of an elemental and concrete sort. In other words, intellectual processes are secondary and derivative processes. They are neither initial nor final. Living beings got experience of a vital sort, very probably, many ages before there was developed the machinery for carrying on reflective functions.

The initial stage of experience is activity. The crude and uncoordinated struggle for existence under conditions of stress, attains its end or not as chance may direct. The end for which these reactions are set up lies in the needs of the organism, and the impulse and instinct serve to bring about relationships between this organism and a larger world, and the satisfaction of these relationships, in turn, sets up still more complex processes. Furthermore, this form of action and reaction, while not reflective in any appreciable degree, serves the purpose of bringing about practical results. A large share of all our acts owes nothing more to intellectual processes than these crude, naive and impulsive forms of conduct. So long, indeed, as conditions remain of a determinate and stable sort, this crude form of endeavor fulfills the demands of life as well as any other.

On the other hand, the highest reaches of experience are not of the reflective processes. Here again, conduct constitutes the funda-

mental characteristic, but now, it is conduct with a more definite viewpoint and a more highly co-ordinated structure, and the individual is certain of his direction. The æsthetic and ethical appreciations reach deeper into the meaning of life than can be stated in reflective terms, yet their content and import appeal so strongly to human consciousness that we act upon this appeal in a thoroughly confident manner. The vague longing and aspiration are likewise implicity trusted, though hardly defined. Art, after all, most definitely universalizes just these appeals, and shows us that conduct constitutes finally the highest of the arts.

Between activity of the crude and undefined sort, and conduct in this highest form, there lies the phase of experience which we name the intellectual type. Its processes form an intermediate and connecting link between the other two. It formulates and estimates the crude experiences, and stands for many possible forms of reactions under given conditions. Since it is out of these crude and concrete activities that the thought process arises, it is at once clear, that the use of the abstract intellectual element as the beginning and end of education is taking it out of its true relations and making it an end in itself. The generalization of this process forms the basis for the dogma of formal discipline, of which we have heard so much in recent years.

Let it not be supposed that I am trying to minimize the place of reason in experience or in education; on the contrary, I would give it the highest cultivation which I possibly could. But, the point is, that it is just one form of the experience process, that it has its own particular limits, function and import; and that it has no more right to stand as the ultimate test of values, in general, than any other form, except for those facts which belong to the distinctively intellectual type.

In almost every discussion of the cultural or other values of this, that and the other subject, the argument is invariably thrown back on this one-sided intellectual basis. Greek and Latin, in secondary and higher institutions, are the greatest cultural subjects, if culture be defined in terms of these subjects themselves or some others like reflective norms. Given this eighteenth century attitude of formal intellectualism and no other estimate can be placed upon such subjects, and we are forever stopped from developing a culture based upon modern science and democratic ideals. Worst of all, this worship at the shrine of particular subjects of the intellectual type, represents the cultural attitude of a society and civilization built on slavery, and, consequently, can never represent more than a partial valuation of life processes.

There are many equally true modes of experiencing reality and our standards of value must take this fact into consideration. Culture, e. g., represents the outlook along any of these approaches to the world's work, and represents, furthermore, the appreciation of relationships to humanity and nature and the forces that work through them. Culture

is only possible in democracy, and democracy is only possible under the fundamental conception of the validity and worth of human endeavor. Life is worth while, and therefore, the instrumentalities through which life works and moves are worth while. From this point of view, each subject has its own cultural value to be estimated in terms of its own type of experience, manual labor as well as any other form. How much outlook is there in what one does; what appreciation does it foster, and finally, what can be done with it?—these are the questions which must be answered in giving cultural valuation to educational material. When once our psychology thoroughly rids us of the hold of formal discipline, we shall be able to place experiences upon their own distinctive merits; and then it will be found that, under the sway of democratic and scientific education and thought, each educational activity serves a clearly defined function, and all finally converge at the common point of sane conduct and intelligent appreciation.

EVOLUTION AND MORAL EDUCATION

DR. THEODORE DE LAGUNA, UNIVERSITY OF MICHIGAN

Whatever separation may ever have existed between the sciences of morals and of education, there was once a time when a dividing line could scarcely be imagined between them—when the fundamental and engrossing question of ethics was: *Is virtue something that can be taught?* and when the all-important problem of pedagogy was: *How shall virtue be taught?* This, as we all know, was at the birth of the two sciences in ancient Greece. Those very teachers, the sophists, who by the novelty both of the subject-matter and of the method of their disciplines had forced educational problems upon the attention of the Greek people, were also the men, who, by their assaults upon the traditional morality, had made a re-establishment of fundamental ethical conceptions the most pressing need of society.

Since the age of Plato, the connection between moral and educational science has never been so close as it is today. Within the last fifty years the evolutionary conception of morals has given rise to problems substantially the same as those of the *Meno* and the *Protagoras,* and, as I believe, their treatment has led to something very like the ancient solution. To point out this analogy, and to show that the most reasonable conclusions of evolutionary ethics with regard to the nature and limits of moral education are substantially identical with the Platonic theory of the subject, will be the object of these remarks.

Plato's principal addition to the theory of ethics, so far as that

directly bears upon moral education, is contained, curiously enough, in his notion of philosophical method, or *dialectic*. Dialectic, as you may remember, is his general term for the process by which the human mind advances to larger and larger conceptions of the nature of reality. It is what he somewhere calls the method of successive hypotheses. A thinker begins by accepting for what it may be worth some more or less plausible conception of reality, and then proceeds to carry this conception out to its extreme logical consequences in every possible direction. In one direction or another these consequences are found to contain some self-contradiction, which prevents their being accepted, and which thus points back to some necessary modification of the original hypothesis out of which the self-contradictory conclusions have come. When this hypothesis has been modified in the manner thus indicated, the same process is repeated. Starting from the modified hypothesis, its extreme consequences are followed out in every possible direction; somewhere a self-contradiction emerges; the hypothesis has again to be modified accordingly; and so on without end. I say "without end"; and yet Plato himself believed that there was an end—a sublime and perfect thought, which should comprehend the inmost essence of all things, and which should suffice to explain the universe to whatsoever mind should attain to it.

Perhaps we may have seemed to wander far away from the subject of moral education; for what has the logical method of the speculative philosopher to do with the process of growth by which a child or a man becomes virtuous? But Plato's doctrine is precisely that the two processes are identical, that *moral strength is dialetic* in exactly the sense which we have just defined; and one of the names which Plato attaches to that most perfect conception which lies at the goal of speculation is simply the *Good* or the *Idea of the Good*. According to him, then, the only way for us to advance in knowledge of the good is to comprehend to the uttermost the imperfect conceptions of life which we now possess. Then only will we be aware precisely wherein their imperfections lie and thus be able to replace them with broader and more satisfactory conceptions. That is why, even as Socrates maintained, the knowledge of the good can indeed be taught, and yet cannot be imparted as so much information. The child or the man must reach it by his own self-criticism, and the only way in which the teacher can aid him is by the directing of his attention to this or that aspect of his conduct which needs criticism. But the criticism itself must proceed from the pupil and not from the teacher; it must be the expression of his own experience and reasoned conviction. Otherwise it is of no real account; it is mere prejudice or opinion, even though it may chance to be correct; it is not true knoweldge. And knowledge, for Plato as for Socrates, is, as you will remember, the source of all virtue.

Now will it be thought an exaggeration if I say that the essence

of the best recent thought on moral education can be summed up in the single Platonic formula, "The acquirement of virtue is dialectic"? That, at any rate, is what I intend to maintain. To be sure, the meaning which we shall have to read into the term *dialectic* must needs be a somewhat changed one. We shall have to allow the emotional side of human nature a much larger share in the process. And yet after all, when agreements and differences are balanced up, I fancy that we shall find ourselves in hearty accord with the old Greek master.

Like almost all the other branches of mental science, the theory of moral development dates a new beginning from the publication of Darwin's work on the "Origin of Species." It was not so much that any of the particular facts that he brought out were of direct use to the moralist or the educator; but he gave to the world of thought certain new points of view, certain new ways of looking at things, that could not fail to lead to important observations.

It must be admitted that the moral theories which were at first connected with Darwinism, were very crude affairs indeed. They were in great part the work of hasty and ill-balanced thinkers, who had perhaps never really mastered the full meaning of Darwin's principles even within the biological realm to which he had applied them—to say nothing of being competent to extend those principles to other realms of investigation and give them in each case the modifications which they required. Or they were the work of professional biologists who had only—as we may say—an amateur interest in ethics, but who conceived that the recent discoveries in their own science had given them a gospel to preach to the rest of the benighted world. It may safely be said that nothing of any permanent value has come to us from the evolutionary ethics of that period. Perhaps, however, the same is to be said of the pioneers in almost every field of investigation; and perhaps, too, we owe a larger debt than at first sight appears, to the evolutionists of the sixties and seventies; since, after all, it was as a result of their misguided disputations that the clearer conceptions which we now possess came finally into view.

As Darwin's main problem had been the origin of species, and the development of the individual organism had been a matter of interest only in so far as it could throw light upon the history of the species—so for the early students of ethical evolution, the all-absorbing problem was the origin of moral sentiments in the human race; and the phenomena which attend the rise of those sentiments in the individual child were not considered to be of anything like the same direct importance for science. Moreover, biological conceptions were in the air and ruled every one's thinking. The moral sentiments were treated as *instincts,* and were considered to be of very much the same nature and origin as the animal instincts of self-defense and protection of offspring. As a matter of fact, a sentiment and an instinct are about as far removed from each other as any two mental or psychophysical

phenomena can very well be; but in the sixties and seventies this was not so well known as it is to-day. And so the problem of moral evolution was regarded as the problem of the origin of a certain class of human instincts, which, like other instincts, had been acquired by natural selection, and were preserved from generation to generation by being passed on from parent to child in the shape of a peculiar congenital disposition of the nervous organism. The child, that is to say, was supposed to inherit from its parents the distinction—or a tendency to draw the distinction—between temperance and intemperance, in the same way that the puppy inherits from its parents a tendency to bury in the ground a bone for which he has no present use. And that, as we shall see, is why the phenomena of the development of morality in the particular child's mind were not supposed to be of very great direct significance for science.

This point is of considerable importance for our present purposes, and will repay a somewhat extended examination. We are all familiar with the so-called *theory of recapitulation*—the doctrine that the individual organism in the course of its development recapitulates the whole process of evolution by which the type of its species changed from a one-celled speck of protoplasm to the complicated structure which it is to-day. Now this theory or law, as you may be pleased to call it, has one very obvious limitation—namely, that the individual development of which it speaks is simply the development of *inherited* characteristics, that is to say, of inherited structures and functions; the theory has nothing whatsoever to do with development in so far as that involves the modification of inherited characteristics or the acquirement of new ones. The creeping instinct which a baby displays some time in the course of his first year is a congenital characteristic, inherited in the form of a peculiar nervous and physical structure; and according to the recapitulation theory it is probable that this creeping points back, somewhat vaguely, to a mode of locomotion which the ancestors of our species practiced before the function of walking on two legs was evolved. Now, to take an extreme instance on the other side, consider the playing of the violin. That is obviously an acquired function; it has to be separately learned by each individual who wishes to have the accomplishment. He needs, it is true, a certain basis of inherited capacity to work upon; he must have, as we say, some degree of musical talent as well as of manual dexterity at the outset; but with all the talent and all the dexterity in the world, no one can play the violin without first learning how. Now my point is that with this acquirement of a new function, this "learinng how," the biological theory of recapitulation has absolutely nothing to do. There may, indeed, be an analogous law affecting acquired characteristics, but if there be such it must rest upon its own evidence; the facts of embryonic recapitulation can give it not the least support.

Let us note, then, some of the consequences which we should have to draw from the old asssumption that moral sentiments are instinctive. We should have to say, in brief, that they are a part of the congenital characteristics of the race transmitted from parent to child, not by education but by physiological heredity, appearing in each child at a fixed time and in a fixed order, determined not by any logical or psychological connection, but simply by the order of their first appearance in the history of the species.[1] And that—to get back to the question from which we started—is why, wrom this point of view, the development of the moral sentiments in the individual child was almost inevitably regarded as of only secondary importance. It simply had no significance in itself at all. It merely pointed back to the order in which moral sentiments had been acquired by the race.

Meanwhile some very excellent work was being done in the study of the development of ethical standards, not in individual men, but in societies; while the moral education of the child was still so grossly misunderstood, valuable light was being thrown upon the moral education of the race. The starting point of this investigation was a sort of modified utilitarianism. Utilitarianism, as we know, is the ethical theory, according to which the end of moral conduct is the "greatest happiness of the greatest number"; i. e., the goodness or badness of an act means its tendency to increase or decrease the happiness of all the men affected by the act. Now the happiness of men is a very difficult matter to investigate, and an algebraic sum of the pleasures and pains of a great multitude of men is practically impossible to compute. So it occurred to various thinkers to substitute for the conception of the greatest happiness of the greatest number, that of the health or well-being of society. Health, of course, is a biological term, and the expression implied a far-reaching analogy between a society of men and a biological organism. The health of a society, like the health of a plant or animal, meant the proper harmonious functioning of all its parts; and it was pointed out that such a condition of affairs in a society was certainly the most important condition for our maintenance of the greatest possible happiness among its members. The analogy of the social organism, like all other suggestive analogies, had its period of usefulness and then fell into neglect as its various points of inadequacy came to light; but while it lasted it served as the basis for those studies in moral evolution, the results of which I shall now attempt to put before you.

If one examines in detail the various virtues and duties which common sense usually recognizes, one readily perceives that these virtues and the performance of these duties constitute the most essentian conditions of social prosperity. Without a certain measure of wisdom the affairs of the commonwealth could not be conducted; with-

[1]As modified, to be sure, by more recent natural selection.

out courage its dependence could not be maintained; without temperance its resources would be wasted; without justice between man and man it would speedily fall to pieces. And much the same might be said of honesty and veracity and benevolence and all the rest of the long list. These are all undoubtedly conditions of social health. Now it was very early pointed out that this fact might explain how it is that these virtues have spread abroad among men. The more virtuous societies have been, on the whole, the stronger both in war and in economic rivalry; they have risen and enlarged their borders, while societies less advanced ir virtue have gone down to defeat. In other words, morality has what the evolutionist calls "survival value" in the struggle for existence between societies. It helps the society which possesses it to survive, while those which do not possess it, perish; and thus, if in no other manner, it spreads abroad over the earth's surface.

This account of the evolution of morality[2] is evidently incomplete in two ways. In the first place, it accounts only for the spread of morality, not for its origin and development as such; and in the second place, it accounts even for the spread of morality only as the society which possesses it spreads, and does not at all account for the spread of morality from man to man within a particular society. Each of these two problems had then to be attacked in other ways.

With regard to the first appearance of morality in the human race, we can scarcely stop to say anything here; for it is one of the most obscure problems within the domain of science. But with regard to the mode in which moral sentiments, already prevalent in a society, are found to develop in the course of time, something very definite can be said. The process seems to be very similar to that by which any useful tool or machine is gradually perfected. A well known analogy is that of the bow and arrow. This species of weapon was at first of a very simple and crude type. Any tough and elastic stick of wood of sufficient length and fair average thickness would do for the bow; and if the arrow were fairly straight and its flint point roughly sharpened, that would serve well enough. But as time went on it was found that such a bow and such an arrow would not always serve. One after another various defects came to be noticed and gave rise to more or less dissatisfaction and desire for improvement. And thus, when, perhaps, a lucky accident pointed to a better way of contriving things, the primitive inventor's mind was prepared to catch the hint and act

[2]In itself, this account marks very little advance beyond the earlier biological view. For it amounts simply to an application of the machinery of the natural-selection theory, to the explanation of the persistence of variations favorable to the survival of animals living together in groups. But in this way the origin of congenital traits alone can be explained; and no doubt certain such traits (notably the sympathetic reactions which lie at the basis of morality are to be thus accounted for. The development of sentiments, however, remains as much in the dark as ever. The real virtue of the argument may be said to have consisted in the obviousness of its defects. A resort to psychological modes of explanation now became inevitable.

upon it. By successive modifications, extending over many centuries, the bow was brought to its perfect symmetry and the arrow was balanced and feathered for its flight. Much the same thing happens in the course of moral development of mankind. Some custom or institution, which is supported by the moral sentiment of the society in which it exists, is found by repeated experiences to be seriously defective. While in general it serves a useful end, and thus confirms to that extent the judgment of past generations; still on various occasions it somehow does not work well and thus gives rise to doubt and dissatisfaction. But this very dissatisfaction contains within itself more or less obscurely the idea of its own remedy—a sense of the necessary limitations of the old law beyond which it cannot be expected to hold. Such a transformation is even now taking place in our popular notions of charity and benevolence. Most men formerly supposed, and a good many men still believe, that giving to the poor, the help of those who are in distress, is always a right act. But within comparatively recent times we have had impressed upon us as never before the lesson that indiscriminate charity may do an immense amount of harm. We have seen repeated instances of its decidedly evil effects. And thus on the one hand we have been led to question the validity of the old standard of right and wrong in this matter, and to lose something of our respect for those who continue to gratify their generous impulses with the old-fashioned thoughtlessness; and on the other hand, we are beginning to see more clearly what the proper limits of alms-giving are. When this change of sentiment has been completely effected, we shall have formulated a new moral law on the subject: "Give to the poor and needy under such and such circumstances; otherwise not." And by this moral law it may be that many generations of man shall continue to guide themselves in their acts of benevolence; until again, in the course of time, this law also comes to show its lurking imperfections, and thus to point to the further limitations which must then be placed upon it. And here, I think, we may begin to observe some justification for the remark which I made at the outset with regard to an essential agreement between Plato's view of moral progress and that to which recent investigation has led us. At least in respect to the race we may certainly say that moral education is a process of advance by means of general conceptions, which, in the very act of applying them, point to their own necessary modification—in short, a process of dialectic. Whether this holds true also of the moral education of the individual, we shall soon consider.

In order to complete our brief survey of the evolution of moral standards in societies, it will be necessary for us to make some observations with regard to the manner in which these standards are communicated from man to man within the same society; and here, at the same time, we shall be entering upon the problem of the moral education of the individual. It is here that we shall have finally to

leave behind us altogether that useful analogy of the social organism; for the process by which judgments and sentiments are conveyed from mind to mind is too peculiar to be explained by any mere illustration.

In the first place, we must note, as in recent studies of society we are so frequently asked to note, that man is an exceedingly imitative creature. I do not mean simply that he is apt to try to do what he sees other men do, but that his very opinions and tastes are strongly imitative of those which he finds prevalent in the socity of which he is a member. Huge as our self-conceit may be, we never become entirely independent of the judgments of our fellow-men. We show this constantly in trivial as well as in important matters. If our neighbor at the boarding-house table finds the butter slightly rancid he takes away our taste for it at once, though a moment ago we may have been eating it quite freely. If he approves of the dessert, that alone will raise the chances of our liking it also. The same is true of our judgments of art. We most sincerely admire many a great poem and many a famous painting which we should have set down as fantastic nonsense had not the approval of the critics recommended them to our notice. And the same again is true of our moral judgments. The decent young man, who thinks gambling and profanity and drunkenness quite wrong and never dreams of indulging in them, is apt to suffer a decided shock to his moral convictions when he wanders abroad into lands where such doings are considered a matter of course. The political reformer fresh from college finds himself within a few months a partner to acts which in former days he would have scorned to countenance, but which his new associates consider perfectly proper. On the other hand, the more our friends expect of us in the way of honesty and temperance, the more we are apt to demand of ourselves. Moral judgments, I repeat, are largely imitative; and even when they are based on reasoned conviction, they are strongly re-enforced by the similar judgments of our neighbors. Here then is one principal means by which moral standards are both maintained and extended within a society.

In the second place, a society is so constituted that the individual man has ample opportunity to verify in his own experience most of the moral judgments which he at first receives from others. He is taught that it is wrong to lie; and the lesson is doubly impressed upon him when a few of his own brood of lies come home to roost. He is taught to be frugal; and he knows well what the virtue of frugality means, when he finds himself able to maintain in comfort those who are dependent upon him. With all its infinite variety, there is a great deal of sameness in human experience; and the fundamental moral laws bear upon just those aspects of life that fall to the portion of all men alike. We have all of us need to be wise and just and brave and temperate and kind; and we can each of us veirfy in their effect upon ourselves and upon those whom we love the value of these qualities

of mind. Moral judgments are imitative, it is true; but they are seldom, if ever, merely imitative; they represent a personal experience which has corroborated the general experience. By such means, then, we may conclude, moral sentiments and ideals are maintained and extended in society.

We are now at last prepared to return to the problem, which, as students of education, concerns us most intimately—that of the development of the child. I have already given you some account of a certain theory of moral development which was quite popular a generation ago—the theory, namely, that moral sentiments are instinctive, transmitted from parent to child by physiological heredity. It should be said, however, that even in the worst period of the biological craze there were not a few men who stood apart from the general current of thought and boldly proclaimed the ridiculousness of the moral-instinct theory. They pointed out the simple, incontrovertible truth, that moral fitness is not acquired by mere heredity; that moral character has its own peculiar means of dissemination; that a virtue or a sentiment is not perpetuated simply because those who happen to possess it are thereby strengthened for the struggle for existence. Kant and Spinoza, yes, and Jesus of Nazareth have not had the less influence upon the moral ideas of mankind because they left no children behind them. In short, moral evolution is not a biological phenomenon at all; it is a matter of training, of personal influences, of education. So far so good. And yet the fact remains that it is quite as possible from this point of view as from that of the biologist to make the study of individual children of very little account for science. For suppose we look upon education as an absolutely irregular and arbitrary performance, not governed by any universal natural laws. Suppose that we are under the impression that what the child learns or does not learn depends upon mere accident, from which no generalization can be made; and that especially in the complexity of modern civilized life no uniformity can be looked for in the conditions under which different children are brought up. Then, indeed, child-study would be for us a contemptible concern; for what could be learned from one child would be of no advantage when applied to another.

The scientific solution of the difficulty—if, indeed for common sense it be a difficulty—came finally in the form of a principle which is known to us by the suggestive name of *social heredity*. The name, indeed, is apt to strike us at first hearing as being very likely nothing more than a figure of speech; but as a matter of fact it means something very definite indeed. In the lower animals the young are provided at birth with a nervous system in which a certain number of definite reactions—some simple, some more complex—are stored up; and these reactions, which we call instincts, include all the more important activities of the animal's life. But as we ascend in the scale of animal life, and the activities which the struggle for existence

calls for become more and more varied and complicated, we find, indeed, sometimes that the instincts become proportionately developed; but sometimes, too, we find that nature has as it were dropped the instinct plan as altogether too cumbersome, and, while leaving the instincts already acquired a somewhat subordinate place, puts her main reliance upon ideas and habits of action acquired by each individual after birth. With such an arrangement, however, there would be a fearfully uneconomical waste of energy, if each generation could not in some way profit by the experience of the last, but had to learn everything over again from the beginning by its own trials and errors. This waste of energy is obviated by that wonderful psycho-physical mechanism which passes under the name of *imitation*. Imitation, then, can be said to play a part in the development of the higher animals, which is analogous to the part played by the inheritance of complex instincts in the lower animals. It is this function of imitation that constitutes what we know also as social heredity.

It is obvious to us upon very slight reflection that in man the part played by social heredity is enormously greater than in any other species of animals; and in almost all human activity the part played by mere instinct seems to be very small indeed. Consider, for example, the great function of speech. This has, indeed, an instinctive basis. The baby does by mere instinct pronounce a number of scarcely artculate sounds, which serve as the beginnings of speech. But all beyond this—all, that is to say, that is peculiar to any one language or family of languages as distinguished from another—belongs to the social heritage; and all this the baby must learn from others. His ancestors may have spoken English for a thousand years; and yet he shows not the slightest observable predisposition to learn that language rather than French, or German, or Turkish, or Chinese. There seems to be no doubt that much the same thing is true of man's moral nature. This has presumably some basis in inherited tendencies of the nervous organism. A certain degree of moral talent is necessary, without which a child is incapable of developing as a moral agent; without this necessary nervous equipment to start with, he remains, so far as morality is concerned, a mere idiot. But all beyond this—all that distinguishes the ethical ideals of modern America from those of ancient Greece or Egypt; all that separates the Christian conscience from that of the most benighted heathen—all this the individual must receive from society.

In a word, the development of morality has been a social process. The individual owes his standards of right and wrong—even as he owes his standards of beauty and ugliness—to the society in which he has been nurtured. His sentiments are echoes; the judgments which he feels called upon to pronounce are imitative of the favorable or unfavorable judgments that are current in his environment; and, as we have already observed, his personal independence never reaches such

a height as to be wholly unaffected by the agreement or disagreement of his associates. This is, of course, especially true of little children. If you repeatedly express to a child a feeling of disgust which is aroused in you by any habitual act of his, he will very soon come to entertain the same feeling toward it himself; and even if the force of habit or of special temptation proves sometimes to be too strong for him, he will be apt to think badly of himself for yielding. And this is but a type of the general process by which, through praise and blame, reward and punishment, the child receives from those about him the great body of moral sentiments which are current in the society into which he has been born.

But this is by no means all that is to be said of moral development in the child. For account must be taken of another great and important factor—the reorganization of the imitated material in the course of the child's own individual experience. The moral ideal is not simply passively received; on the contrary, it undergoes in the individual a development which is closely analogous to its evolution in society. To this point we must now devote our attention.

When a child receives into his mind some judgment with regard to the rightness or wrongness of certain modes of conduct, the judgment does not lie there idly as so much mere information; it is applied and acted upon, and it is only in being thus applied that its full meaning comes gradually to light. Just as a child's first imitations of the words which he hears are crude and inexact affairs; just as his first drawings are almost unrecognizably schematic; so his earliest moral judgments are far from representing with any adequacy the opinions which he has heard expressed by others. How then does his development proceed? Well, as I was saying, the crude judgments that have been received are acted upon. So long as the consequences of such actions are satisfactory to all concerned, the underlying moral judgment need undergo no change. But occasionally it happens that the consequences are not wholly satisfactory; and in particular they are found to work injury to other persons, including those to whom the child is especially attached. Thus there is brought into operation a certain more or less powerful motive—the tendency to sympathetic feeling, which is congenitally present to some extent in all of us; and by reason of this feeling, the child finds himself dissatisfied with the course of conduct which has given pain to others. The dissatisfaction thus arising becomes then the core of a modified moral sentiment, of a new judgment which is not founded upon faith alone, but in part, at least, upon experience and insight. This is the process by which each one of us has arrived at what degree of comprehension he possesses of the meaning of the moral code which governs society. It is only by obedience to the law, as our ignorance conceives it, that we can ever attain to a better understanding of its significance.

This now, is what I meant by saying that we stand to-day in an

essential agreement with Plato's theory of moral education. For us, as for him, moral education is dialectic. It is the very persistence in an ideal that works its transformation, because it necessitates its application to unforseen conditions. The accepted standard of action—say in truth telling—when viewed abstractly, appears to be final and altogether perfect, as if it were always right to tell the truth and always wrong to tell a falsehood; but when the standard is applied in practice it reveals unexpected shortcomings—inconsistencies of such a sort, that it defeats its own end and gives rise to dissatisfaction and unrest. But this very dissatisfaction contains the idea (more or less explicit) of a modification of the old ideal by which a more adequate principle of conduct is revealed. Hence arises a dialectical development of the ideal, by differences, which are for the most part slight, but which may, at critical periods of a man's life, be momentous and profound.

Let us now for a moment consider the very different conception of the relation between individual development and race development which this theory suggests, as over against the conclusions which we drew a little while ago from the theory that morality is instinctive. We found, you remember, that so long as moral sentiments were conceived of as being passed along from one generation to another by mere physiological heredity, the manner and order of their appearance in the child had no intrinsic significance that psychological analysis might reveal; it was but a record of the order in which, through natural selection, these instincts had been acquired by the species. Thus the only significance of child-study for ethics was that in a very indirect and imperfect fashion it helped to supplement the great gaps in our knowledge of the history of human morals. Many phenomena of child-life, which have a fixed order of appearance, markedly unaffected by external circumstances, are, indeed, satisfactorily explained in just this way. But if the development of the moral sentiments is a process of a radically different sort, determined by variable factors of individual experience such as sympathy and imitation; then, without unduly stretching our terms, we may say that it is now the individual development that must be regarded as the complete process, of which social evolution is the imperfect recapitulation—imperfect, that is, because in it are obscured those all-significant facts of individual experience, by which in the last resort social evolution itself must be explained.

For the teacher and the social reformer, this general conception of the process of moral development appears to be most satisfactory. If the power of heredity were absolute, it would set a fixed limit to the possible success of all their endeavors for the moral improvement of mankind. Or if morality, like musical ability, depended largely indeed upon training, but, if anything, more largely still upon a native endowment that is anything but universal among men, the possibilities of extensive improvement would still be proportionately small. The case,

however, appears to be more fortunate. Morality, like the other great universal function of language, is, as we have said, pre-eminently a social growth. It rests upon a minimum of inherited capacity and exhibits a maximum of responsiveness to culture. Society, then, has every chance to improve itself morally, so far at least as the most general conditions of such improvement are concerned.

And yet the case is not quite so optimistic as one might first suppose. For we have still to remember that moral development, even if it be not predetermined at birth, begins its course very soon after birth, and the influences of the first few years are doubtless quite as important as common-sense has always affirmed them to be. The first seven years of life was all that the Jesuit asked for in which to fix the religious convictions of a child; and these years are not less decisive of at least the general course of moral development. To be sure, there is always the possibility of reform, just as there is always the possibility of religious conversion. But even the most radical reform and the most thorough and sincere conversion must leave untouched the greater part of the impressions of infancy.

That is one reason why I particularly like the term "social heredity." For, after all, we cannot fail to recognize that it is a species of heredity as truly natural in its way as that by which the bodily organs and functions of the species are perpetuated. It is not alone his parents' features that the child inherits, but their habits and tastes and convictions and ideals. It is commonly said that man belongs to a class of animals that are completely formed at birth, and the saying is true in a sense; but in a very important sense it is not true. For as the young marsupial must be carried for a time in his mother's pouch until his physical development is complete, so the child must remain for a more protracted season in the family until his development as a social being is complete; and the family is every whit as natural an organ as the pouch of the marsupial. Social heredity, I repeat, truly deserves its name, and during the years of infancy it pursues its course with the pitiless inevitability of a natural process.

Still, after all, the reflection remains that moral education is more even than a socially determined process. Our final word must be that it is not mere heredity, but dialectic, not mere development, but self-development. There is a power within us that shapes our ends, rough-hew them how destiny will. It is only by appealing to this power that the educator can reach the moral nature of a man or a child. This is the enduring truth of Plato's pedagogy. Virtue cannot be taught by mere imitation, because it does not pertain to a being that acts by mere imitation. "But as conduct proceeding form personal insight, from inward conviction and *knowledge,* in which alone it really consists, it is entirely teachable; for the secret of teaching it lies in arousing the power of thinking"[3]—that is to say, in directing the process of dialectic.

[3]Quoted from a privately printed essay of Professor G. H. Howison.

THE CHILD AND HEREDITY

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All education must be founded upon the nature of the child. The trainer of animals first learns all he can about the natural characteristics of the animal he is to train, but the human animal is often trained by those who never give a thought to its nature. The treatment of the child in the home from infancy to maturity, in school from the kindergarten to the end of the university course, in life from birth to full stature, can be wise and most valuable only when it is founded upon a scientific basis. We may work the greatest injury by demanding of the child the right interests and abilities at the wrong time. The tendency of education has ever been to project the conceptions and emotions of the adult down into the life of the child and to demand the reactions which should be given to those conceptions and feelings. We must look at the child from a different point of view. The old conception of child-life has wrought great injury in education and the treatment of the child both at home and in school.

Two great laws of biology must be thoroughly understood before we shall ever appreciate the child's life and point of view. The first is the old and well-established law of biology, that the embryo of every species passes through in its development all those stages of growth which its ancestors have passed through in their development from a one-celled organism. The second is a new and as yet generally unknown law of heredity, which is that the young of any animal passes progressively through all stages of heredity from the oldest and most primitive types down to the last and most recent type. These two laws apply as well to children as to the young of other animals, and when fully understood explain many features of child-life which hitherto have been inexplicable.

Child-study, which is the youngest of all the sciences, is founded squarely upon these laws and looks at the child from the standpoint of evolution. Any other point of view for the study of the child leads to the most absurd and sentimental conclusions. The first law which I have already given, may be understood from a single illustration. Its application to child-life and education is far more general than it may seem from the discussion given to it here.

Cope exhibited at the World's Fair in Chicago a few teeth from an embryonic elephant, which in themselves were interesting, but were of far greater importance to the world of science than was generally known. There had been a discussion for many years over the origin of our modern elephant. Most scientists declared that the elephant could not have descended from the mastodon because of the enamel plate

which is characteristic of the tooth of the mastodon, but is not found on the tooth of the elephant. Cope said that if the law of biology is true that the embryo of every species passes through in its development all those stages which its ancestors have passed through from a one-celled organism, then the embryonic elephant would at some time show the enamel plate on its teeth if its ancestors were mastodons. Accordingly the Asiatic elephant, which is the oldest type of elephant, was taken, and from it a half-developed embryo secured, and there on the teeth of this developing elephant was found the heavy enamel plate reaching half way up the length of the teeth. The plate forms there, but is all re-absorbed before the elephant is born. The embryo which they found was passing through the mastodon stage, and would have been born an elephant.

The same law applies to the human child. It passes through all the phases of development which its ancestors have passed through in their development from a one-celled organism to the appearance of man as such upon the face of the earth, before the child is born. I have seen two children within a week which were born with the gill openings still manifest in the neck. All children pass through that stage of evolution in which the oxidization of the blood takes place through gill openings instead of through the lungs, and frequently children may be seen which have been born without the entire removal of the first process of the oxidization of the blood. But while that great law of biology is valuable in order to give us a point of view for studying the child, placing us squarely and unwaveringly upon the theory of evolution as a basis for observing and educating the child, still the second law, which may be called the law of heredity, is far more immediate in its application to all stages of post-natal education of the child.

The old theory of heredity was that the child inherits the past, with all its various phases, *at once,* or that all the past has its influence upon the child from the moment it is born. It may easily be seen that such a view of heredity will not withstand a moment's criticism and analysis. The infant is influenced only by the hereditary influences which are of prehistoric man, and it is not until the child reaches the height of the adolescent growth, or until the child is thirteen to sixteen years of age on the average, that it begins to inherit or be influenced by the hereditary forces of its immediate ancestry, where by "immediate" I mean the last five or ten generations.

Let us notice this law of heredity as seen in animals. We are all familiar with the fact that a white horse is born neutral gray or mouse-colored. The colt of any particular breed of horses usually does not show the characteristic red or the characteristic black or white of that particular breed until it is several months old, or until it has shed its first coat. The Jersey calf on the first day of its life does not show the characteristic fawn color, with the squirrel-gray markings, shading into

brownish black, but is a neutral shade of red. The red might deepen into the Durham red or it might pale to the Jersey red. In other words, the color of the colt and the calf are generic colors and do not take on the specific shades until the young animal has matured sufficiently to come into the field of heredity which is determined by its immediate parentage. Its color is the color of the primitive animal.

We see exactly the same thing in children. Our most beautiful men and women are frequently of Celtic blood. But those same beautiful young men and women were the most freckle-faced, red-haired, scrawny-looking children that could be found in the neighborhood. I have watched with great interest the development of a family where the mother is Irish and the father is Scotch-Irish. The children are perfectly in line with my previous description, while they mature into the most beautiful young men and women that I have ever seen. Wherever you see a racial stock which is persistent in its characteristics, as is true of the Celtic stock, you will find the child is very primitive and crude in its physical appearance and only comes into the magnificence of its ancestral characteristics in the adolescent years or as he approaches full maturity. We see the same law illustrated in the fact that most Anglo-Saxon children have light hair, which takes the family hue in adolescence.

This same law of heredity is shown well in the intellectual field. It was a great surprise to many a teacher at the close of the war to find that the freed slave child would learn just as fast as the child of the college professor or president. It is still a surprise to most educators that the Indian child, the children in the slums, and the child of the negro or any other undeveloped race will learn just as fast as the children from the best and most cultured homes, and, if put into those cultured homes side by side with the children of cultured parents, would be fully on a par with those children all the way from infancy to adolescence. It is no surprise at all to the person who knows the law of heredity by which we see that the immediate ancestry of the child does not affect it at all intellectually, providing that ancestry has been reasonably clean morally, until the child reaches the adolescent stage of development. The infant is a child of the race, and one infant will learn as fast as another, all other things being equal; but in the adolescent period the child of the cultured and trained ancestry will strip ahead and forever leave behind the child of the uncultured and uneducated race.

This is seen also in the case of insanity. Primitive people are not insane. Who ever heard of an insane savage? Who ever heard of an insane child? It is not until the child becomes an adolescent that it reaches that stage of its heredity where insane ancestors will have any influence over it whatever. Weismann set forth a most interesting theory, which some swallowed with great eagerness because it seemed to deny the law of evolution; but in his assertion that it is impossible

to inherit acquired characteristics he was childishly weak and decidedly premature in his conclusions. He had tails of mice from some three dozen generations which had been cut off from all the parents, so that the young descended from bob-tailed mice and yet the tail of the thirty-fifth generation was just as long as that of the first generation, and he therefore assumed that it was impossible to inherit an acquired characteristic. If he had been much of a scientist it might have occurred to him that the removal of a rudimentary organ would not very seriously affect the heredity. I have seen the horns removed from cows and bulls, so that within a few generations Jersey and Ayrshire calves were born, like all other calves, without horns, for that is the primitive condition evidently; but they never developed horns, which showed the influence of the immediate ancestry and proved that an acquired characteristic, even when violently acquired, may be transmitted. But Weismann's general law is absolutely short-sighted, because it never apparently occurred to him that heredity comes out in progressive and successive stages, and that the color and education and artistic ability of parents and families is not inherited by the child until the close of its full maturity. His argument, therefore, that the child of uneducated people learns just as rapidly as the child of educated people is true for the period of childhood, but it is not true for the period of adolescence, at which time the culture of the last few thousand years tells upon the developing child.

Another fact should be put with the laws which we have been discussing, and should always be remembered when reading works of evolution, and especially those of Darwin. The fact is this: There are substantive and transitive stages in evolution. There are times when the change has been sudden without any apparent connections or intervening steps, and again there have been long periods when the evolution seemed to be arrested. These transition stages are hard to catch in the development of the child or embryo, for in a few hours the embryo might pass from one stage to another, while the substantive stages are easily studied, for they remain much longer.

That great law of biology has a more extended application, for it includes infancy as well as the embryonic stage. It may be stated this way: The young of any animal passes through, in its pre-natal and post-natal development, all the stages which its ancestors have passed through in their development from a one-celled organism. The more immature the offspring at birth, the more of the development takes place after birth. In this light we must look at the human infrant, which is relatively very immature at birth, and therefore shows many of the stages through which the genus homo has passed. Interesting as the study of the human embryo is, it has little bearing on education, for the child at birth has passed through all pre-human stages—if such an expression may be allowed. Strictly speaking, the human race goes

back to the one-celled organism, and every human being begins there and is human from that moment.

The child is born with those physical characteristics and mental instincts which belong to primitive man, and if studied carefully it is hardly recognized as one of its species. Its body is unlike the adult body, and its instincts all belong to a life we know nothing about. It fears things that are not fearful, and does not fear things that are deadly. It will scream at the touch of fur perhaps, and at the sight of a mouse, but show no fear of a locomotive or automobile.

Physically, you say the child is just like its parents. Yes; but you are not a good observer if you say that. First, notice its relative parts. Its head is one-fifth of its total length, while in adult man the head is one-twelfth of the total length. The child's body is narrow from shoulder to shoulder, being only a little wider than the head, but is very deep from front to back. That relation in itself often marks the late formed man from the man of primitive times. The arm of the young infant is remarkably well developed, and its hand grasp is so great that it will support its weight with one hand longer than the best athlete. It could not stand upright if it had the strength to do so, for its legs cannot be placed in line with the spine. They hang forward at nearly right angles to the body, the lower leg falling naturally from the knee. The feet turn inwards, and the bottoms can easily be placed flat together. The young child in school often stands on the sides of the feet to rest the ankles, for the flat-to-the-floor position is not natural and must be rather painfully acquired. The foot of the babe is also prehensile. All this tells of the tree-climbing stage, and the babe at birth is relatively about as far toward full manhood as the adult was in the prehistoric stage when man lived much of the time in trees and took to them for safety, having no other means of escaping his worst enemies.

The internal organs of the child are quite as much unlike the adult's. A careful study would reveal the fact that many of the vital organs are so different in the child from what they are in the adult that they could not be used to identify the species if other parts were not seen. The heart is very small in the child and the arteries very large. The stomach is vertical, while it is horizontal in the adult. There are many other differences.

On the mental side we find the child full of instincts that are purely feral. Among them is fear of fur, big teeth, feathers, gruff voices and water. These fears appear without any experience on the part of the individual and are wholly teleological. The child in primitive times must have those fears to survive. They cause the child to shriek with alarm when it knows nothing about the meaning of the object. The child in primitive times must shriek when touched with fur, or die. The shriek became an instinct and is set on hair triggers, timed to go off at the instant of contact with the dangerous fur-bearing

animal. One child in about five today has not outgrown that fear before birth.

The fear of the darkness is interesting from this standpoint. An infant is not afraid of the dark. This fear comes on about the third year, and not till the sixth year sometimes. It is not an acquired fear, as most mothers suppose. It is purely instinctive, and hence is so hard to reason against. We cannot control an instinctive fear, but may control a fear which we have acquired, such as fear of cars and fear of being thrown from a carriage.

In primitive times the mother would always come home at night and bring nourishment and warmth and comfort to the babe in the cave or tree-top. It was the best time of day for the child. Later when others held the mother's attention the older child was weaned from the parents and driven away. Night without shelter, food or protection was a terrible thing. Darkness meant horror to the large child. Fear of darkness tells then of childhood, not infancy of primitive man.

Then comes the cruel stage. Man has had an awful struggle with other animals before he learned to use fire for protection. It was kill or be killed, eat or be eaten at sight. The child may be frightfully cruel and desire to kill Indians or tigers or other big game, and play those games on other children or animals. It is a phase of growth, and unless outgrown results in murderers or very cruel men.

At about 8 to 15 we meet in the child another substantive stage of growth. It is one of those long levels that the child does not get over easily. At this period of the child's life he resembles primitive man as we find him today in the Gypsy, Tasmanian, Bushman and some of the islanders. The boy of 10 is hardy, capable of caring for himself better than ever again in his life, sly, well knit, and morally primitive.

It is a rare thing for a child to die between the ages of 9 and 12. The death rate is lowest at that time. The child almost stops growing for a few years; some never do grow after the ninth year. The boy of 10 years has a slender leg below the knee, short thigh bone, low bridge to the nose, no beard, and in many other ways resembles the primitive savage.

In this period of his life certain tendencies appear which are as primitive socially and morally as his body is physically primitive. One characteristic is lying, and another is the tendency to take things which do not belong to him. The child is easily influenced to commit crimes, especially against property, when about ten to twelve years of age. Parents and teachers must deal wisely with this period. One could recite for hours instances of misguided parents who tried to whip out of boys and girls the tendency to steal when they needed nourishment, for they must outgrow those tendencies if ever fully cured of them. When we realize that the child is good naturally, and that tendencies to lie and steal and do evil things are evidences of poor example or

poor nutrition—same thing in either case, for both of them are forms of ill nutrition—we have gone far toward the salvation of the child and the prevention of crime.

Another tendency which crops out in these years is that of truancy. This is a racial instinct which dates back to the time when man wandered up and down the great rivers, following the migrations of fish, which he had learned to use for food. The Gypsy and other primitive tribes wander still. Dr. Kline, in his studies of truancy, finds that out of 250 runaway boys 91 per cent ran away in the spring or early summer, and 4 per cent in the fall and only 1 per cent in the winter; the others at all seasons of the year. We all know what feelings of unrest come with spring days and how easy it is to drop work and go somewhere. I knew one woman who moved in her own house every week, and her son ran away every year in April, returning only after several weeks, but was a good boy the rest of the year.

Dr. Kline has done another service in showing that runaway boys are smaller than they should be, considering their parents and nationality and all conditions. From this he concludes, and is supported by Dr. Hall, that truancy is due to lack of nutrition, which brings up the instinct that primitive man had when hungry. Not only do children wander when poorly fed, but men may revert to this habit when life conditions are not endurable. The tramp may be explained on this basis alone. The child in this stage of his growth, if poorly treated or poorly nourished, or if the old instinct impels him, will jump onto a train or run away and go to sea. A few trips and the old racial habit is awakened and he becomes a confirmed tramp.

Lack of nourishment may be due to inability to assimilate food as well as to insufficient supply. The boy who ran away in April every year was only five feet six, while his four brothers were over six feet tall, and all ate at the same table. He had some nervous degeneration which rendered his system incapable of taking in nourishment enough to cause full maturity, and, reverting in size, he reverted in habit also, to primitive man.

Truancy, like crime, is curable by good food; but whipping only increases the tendency, or brands in the old marks. All instinctive acts of this nature must be outgrown, and good nourishment is the essential factor in growth; but the mind must be stimulated as well, that moral support may be given. No amount of moral and religious training can make a moral man out of a degenerate, however, unless he can be developed into higher conditions of life.

Our prisons and asylums are full of people who are there because they were not treated properly at the age of 8 to 15 years. They are all cases of arrested development.

Nature struggles hard, but finds it difficult to bring each individual through all the lower stages up to its highest perfection. It is so much easier to make a second class than it is to make a first class man or

animal. It is the highest and last stages of growth that cost most. Many are the causes which prevent perfection of the individual, but they all result in one way or another from lack of nourishment.

This applies as well to the mental life as to the physical, and when we find arrest in growth of body we usually find arrest of growth in mind and morals as well. The spiritual nature being the highest and last to develop, many individuals are arrested before their spiritual growth has been attained. Perfect man is religious. The dwarf and degenerates are not. In good development will be seen a well-rounded spiritual as well as physical life.

The second division of a life cycle we call the adolescent period. This is in many ways the most important phase of growth. Adolescence means growth and is applied to that period in which the child grows from the long level of primitive physical and mental conditions into his more recent heredity. The infant inherits the prehistoric ancestral conditions, the boy of ten the conditions of mediæval man, or man at the time of migrations, and adolescence brings him out into the inheritance of historic or modern man. Without this last growth the child remains a primitive being. He may be sharp, able to care for himself, cruel, deceitful and cunning, but small in all the higher phases of life.

When we understand the meaning of this adolescent growth we shall see the importance of making much of it. Its characteristics are interesting and must be dwelt upon briefly.

When the child enters this adolescent stage one of the first developments is in the diameter of the heart. In infancy the diameter of the heart is to the diameter of the artery as 25 to 20; at the beginning of adolescence this ratio rises to 140 to 50, and during adolescence it rises to 290 to 61. In a word, the pressure of the blood changes fivefold or more. This alone accounts for the great impulsiveness and unbounded energy shown by the child in the teens. Next comes rapid growth in height. For the previous four years the child may not have grown more than half an inch a year, and now may grow an inch a month for as many as eighteen months in the extreme case I have observed, while an inch a month for several months is a common growth. Primitive man is short, modern man is tall.

This rapid growth in height is accompanied with changes in form and features. The nose changes shape rapidly, assuming for the first time the adult form. The brow, cheek bones, chin, forehead, color of hair, length of thigh bone, breadth of shoulders and hips, and voice change rapidly. It is called a physiological second birth.

While these changes are going on in the body there are as great mental changes. There is one general difference between the child and adolescent. The child lives in the real of the senses, the adolescent in the realm of thought. A boy spends two hours a day on the average, it is said, trying to make some new noise. While sensations are new

and frequent the child is happy, but has no resources in time of calm or the dark closet. The adolescent awakens to the meaning of life. He sometimes starts up with questions as if he had never seen the world before. Who am I? How do I know that I am I? Are these people my parents? How do I know? Who made the world? Who made God? Is there any God? Is the world real?

With his heart pumping blood through his arteries with an unwonted vigor, with new areas of his brain bursting into function, with ideals of grand heroic life, and with magnificent visions of what the future will bring him and of his own greatness, he is still treated like a kid and often tied up with red tape until he explodes from excess of unused energy.

Adolescence is a time of great and intense interests in reading, music, art, science, athletic sports; there are periods of great energy and sloth, of despondency and joy, of rebellion against home and school and all authority, of deep selfishness and as well of great generosity; emotions are strong and uncontrolled because new and unknown, and because the character has not settled. It is the time of forming the greatest ideals of life, passionate longings, the first feelings of love, and, best of all, it is the time of the blossoming of the spiritual life.

Allow me to give instances of these new stirrings in the soul.

Parents seldom realize, for they have forgotten their own adolescence, the intense desire to read which comes to the average boy and girl at 13 years of age. Franklin read poetry all night at about 13; wrote it also, and sold his poems on the street. Joseph Henry, president of the Smithsonian Institute, accidentally got into the library at Albany and read all the fiction and all the science in systematic order. Edison tried to read through the Detroit free library, and read 15 solid feet, beginning at the lower corner so as to take it systematically.

It is the golden opportunity to furnish a taste for good literature and innoculate against the worst forms of the reading habit.

Interest in music is also intense. A little girl of 15 wanted to compose one piece that would enrich all subsequent life. It is the time of the awekening of the soul to a sense of the beautiful. Seventy-five per cent of young people have a deep interest in art at about 14 to 18. They are just discovering the beautiful things in nature and life.

Said a young woman: "At 17 I meant to be a great artist. I purchased an outfit and began, but the spell soon passed away."

Another: "At 13 I longed to be a sculptor. That passed, and now —18—I want to be a musician."

It is the period when most of the great scientists got their first love for nature and research. Banks, the great botanist, was idle and worthless till at 14 he came out of the swimming hole late and walked home. He was so impressed by the beauty of the flowers on the roadside that he at once began his great career. (Score one for the boy who was behind time.) Everyone knows how the boy is interested in

sports, athletic events, horse racing, prize fights. He is not worth raising if he is not interested at 13 to 18 in such things, and not fit to live unless he outgrows most of it when he gets to be a man.

Periods of languor, inertia, laziness of both mind and body are followed by periods of abnormal energy.

F., 24: "At 16 I had such a spell of energy that I took the parlor carpet up, cleaned it, moved all the furniture, including a piano, out of the room, washed floor, put down carpet and put all back in place, and was not tired. It would have killed me ordinarily, for I am not accustomed to work. Wrote an essay in such a mood at 23, and it was criticised as not sounding original."

F., 16: "I sometimes stay in bed till noon and sit around the rest of the day. Again, I do unnecessary work in spells of great activity."

The sad side of it is that there are spells of great despondency, often culminating in suicide. This should be better known. Despondency is a natural phase of growth, and is strongest at 17, and should decline and pass away at 22 to 25. It is caused by the new body and brain functions and the general rapid change in the organism, coupled with the great fluctuations of the emotions.

It is also a time of rebellion against home and all authority. There is a deep longing in the soul for larger things, for change and for self-expression. Maturity calls for independent action. Elopements, separation from home, truancy or disobedience at school, sudden bursts of anger directed at the parent or teacher are common, and should not be assigned to a spirit of total depravity, but more likely to an unsympathetic relation of parent to child in the home, and a childish government at school.

A boy of 14 was so selfish that it was considered a family calamity. He was as generous and noble as his brothers in two years' time. A large and brilliant young woman of 17 was so cross as to destroy the home life. She said: "Mother, I know that I make life wretched here for all of you, but you don't know how cross I feel." She outgrew it at 19, and is a beautiful, sunny character at 23.

The adolescent often makes friends with older or younger persons for no other reason than to avoid sarcasm and find sympathy. The adolescent boy often falls in love with a woman 10 to 15 years older than himself, because they are more sympathetic than girls of his own age.

Religious life comes out naturally at 14 to 16 and is the last and noblest emotion of the soul. It comes about the time of love for the opposite sex, and because the highest and best should not be forced into expression when half mature any more than love should be forced by flirting. In either case we get an uncertain, namby-pamby, milk and water emotion which is luke-warm and sickening. The strongest emotions are those which are held in check till their full maturity.

To gather up the fragments of this paper, then, we must look at

the child form the standpoint of development, must understand the origin and meaning and time of development of its instincts and emotions, its longings and unrest, its feelings for home and authority, and must keep the child growing.

Nothing is so bad as arrested development. Nourishment, variety of food and plenty of it, especially such food as the child craves, must be given. As the child comes to the period of retarded growth and wandering instincts, special care must be given to its moral life and food. In the adolescent there is need of sympathy, life, inspiration and protection from moral and social crimes, for the impulses are stronger than at any other time of life, while the powers of inhibition and restraint are almost unknown. A sympathetic touch of an older and stronger friend will save many a boy and girl.

OVER-PRESSURE IN THE HIGH SCHOOL

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To assume that there is such a thing as overpressure in the High School may seem to many teachers like creating a ghost for the mere pleasure of dispelling the illusion. Nevertheless, this ghost is bound to stalk forth periodically in the minds of certain over-anxious parents or in the columns of some newspaper seeking an argument against the school administration. Even in the theorizing of some educators it is charged that the high school curriculum, with its present-day wide range of studies, and with its library and laboratory methods of teaching, is making unreasonable demands of the youth who undertakes to complete the course prescribed for graduation. Some time ago a paper was read before the Collegiate Alumnae of Detroit in which it was charged that the sessions were too long; that if the pupil did conscientious work, the course of study required from four to five hours per day at home; that to meet the college entrance requirements in the twelfth grade meant five or six subjects, with from five to six study hours each day, and that these conditions were injurious to the health and proper development of the pupil. We are all familiar with the complaints of the parents when perhaps the only child has been reported to be doing unsatisfactory work in a certain subject. Then the lessons are too long and difficult, the teacher expects too much of the pupil, and, if that parent was once a school teacher, we learn that the present tendencies in education are all wrong and that present methods can not be compared with the old of some uncertain number of years ago. We may listen patiently, and yet we know that the course of study is a growth developed out of the experience of years. We know

that the demands of a course of any value must make the student work, and we also know that we can not demand more than the average pupil will do with an average amount of effort. We should like, no doubt, to plan our work to suit the abilities of the brightest students in our classes, but the universal experience is that of a teacher who said a few days ago: "I have six pupils in my geometry class—numbering thirty-two—who are absolutely dull, and all my work is gauged to meet their demands."

It is practically impossible to make the teachers believe that there is overpressure from their standpoint. On the other hand, many parents feel that there is an excessive demand because they can not see their own children as others see them. There is, however, a third party in this discussion that, it seems to me, is the one who really knows, if he would tell it honestly, more about this question than anyone else—that is—the student himself.

To observe the actual condition and to better judge of the question of overpressure, I have attempted in a very few days allotted to me to make an investigation in the Central High School of Detroit. This school is the largest in the state, and is in many ways a representative school of high grade. As to its standing at the University, the record of its students proves more clearly than can any other argument the quality of its preparatory work. The record of the school for the past semester shows that the percentage of success was 88.51, that of total failure but 7.04 per cent, and the conditioned made the remaining 4.45 per cent. I state this for fear that some may feel the following record might indicate that satisfactory work was not being done and that our standards were low. The purpose of the investigation was to obtain an unbiased, free expression from the pupils themselves, and to secure a truthful record of work actually done for one entire week. Blanks of the following description were handed to each pupil:

Two or three days were taken for explanation before a record was begun, that it might be done correctly. It was made a voluntary matter, though all were urged to aid in securing a truthful record for the entire school. In returning the blanks filled out, the student was not obliged to sign his name, as he was assured that the purpose was not to investigate his personal record. Possibly the fact that it was so impressed upon them that only truthful and accurate reports were desired caused many not to hand them in. Full statements were obtained from 1,431 students out of a possible 2,000. While it would have been desirable to have had a more complete report, it is believed that the more reliable records were those handed in, and, therefore, we are able to draw from them the more accurate conclusions.

From these reports were obtained the time spent in recitations, in laboratory work, on subjects in which they had failed, and the time spent in the preparation of each study. The form used for illustration is an actual report of a first year student. When he handed it to his

principal, she remarked: "Why, Ralph, you forgot to copy the time spent in English!" His reply was: "You told us that this must be an honest report, and I didn't study my English this week." This report possibly represents the work of an honest boy who does as little studying as he can and at the same time keep from failure.

To judge properly of the results of this investigation would necessitate a certain familiarity with the course of study and a knowledge of some local conditions. However, a brief view of the course of study will show a few features that in part will explain some of the apparent peculiarities of the tabulated results.

9 B.	9 A.	10 B.	10 A.
English (1)..... 4	**English** (2)..... 4	**English** (3)..... 4	**English** (4)..... 4
Alegbra (1)..... 5	**Algebra** (2)..... 5		
.....	.....	.....	.....
			Alegbra (3)..... 5
		Arithmetic (1)... 5	Arithmetic (2)... 5
History (1)..... 4	History (2)..... 4	History (3)..... 4	History (4)..... 4
Latin (1)..... 5	Latin (2)..... 5	Latin (3)..... 5	Latin (4)..... 5
French (1)..... 5	French (2)..... 5	French (3)..... 5	French (4)..... 5
German (1)..... 5	German (2)..... 5	German (3)..... 5	German (4)..... 5
			Botany (2)..... 5
Geography (1)... 4	Geography (2)... 4	Botany (1)..... 5	Zoology (2)..... 5
		Zoology (1)..... 5	Physiology (1)... 5
Book-keeping (1). 5	Book-keeping (2). 5	Book-keeping (3). 5	Book-keeping (4). 5
		Phonography (1). 4	Phonography (2). 4
*Drawings (1)... 4	*Drawing (2).... 4	*Drawing (3).... 4	*Drawing (4).... 4
*Manual Training (1)... 4	*Manual Training (2)... 4	*Manual Training (3)... 4	*Manual Training (4)... 4
Physical Culture (1).... 2	Physical Culture (2).... 2		
11 B.	11 A.	12 B.	12 A.
English (5)..... 2	**English** (6)..... 2	**English** (7)..... 2	**English** (8)..... 2
Geometry (1)... 5	**Geometry** (2)... 5		
.....	.....	.....	.....
		Literature (1).... 4	Literature (2)... 4
			Algebra (4a).... 4
			Algebra (4)..... 2
		Geometry (3).... 3	Trigonometry (1). 4
History (5)..... 4	History (6)..... 4	History (7)..... 4	History and Civics 4
Latin (5)..... 5	Latin (6)..... 5	Latin (7)..... 5	Latin (8)..... 5
French (5)..... 5	French (6)..... 5	French (7)..... 5	French (8)..... 5
German (5)..... 5	German (6)..... 5	German (7)..... 5	German (8)..... 5
Greek (2)..... 5	Greek (3)..... 5	Greek (4)..... 5	Greek (5)..... 5
German (1a)..... 5	German (2a).... 5	German (3a)..... 5	German (4a)..... 5
French (1a)..... 5	French (2a)..... 5	French (3a)..... 5	French (4a)..... 5
Chemistry (1).... 5	Chemistry (2).... 5	Physics (1)..... 5	Physics (2)..... 5
Com. Geog..... 5	Com. Law (1)... 5	Economics (1)... 5	*Office Practice... 4
Phonography (3). 4	Phonography (4). 4	Phonography (5). 4	Phonography (6). 4
*Typewriting (1). 4	*Typewriting (2). 4	*Typewriting (3). 4	*Typewriting (4). 4
*Drawing (5).... 4	*Drawing (6).... 4	*Drawing (7).... 4	*Drawing (8).... 4
			Reviews 5

The number of hours required for graduation is 142.
The subjects printed in heavy type are required.
Before graduating ALL students must have completed:
Four years of English.

Two years of mathematics (one year of algebra and one year of geometry.)
One year of history.
One year of science.
Students electing a study running through a year must complete the year's work in that study before any credit is given, except in cases granted by principal.
The number in parenthesis, following the name of each study, indicates the number of the course in that study.
The number opposite the name of the study, at the right of the column, indicates the number of recitations per week for that study.
Drawing, Typewriting, Manual Training and Office Practice receive two hours' credit per semester. Reviews also receive one-half credit.
Physical Culture is required of first year students, but does not count as credit for graduation.
The arrangement of subjects by grades is not restrictive, but indicates the natural order to be followed in any line of work.

A study of the foot notes may be sufficient to understand the curriculum. A large proportion of the students in the second year are taking some of the biological studies, which are taught mainly by laboratory work, and this, with bookkeeping, drawing and manual training, for which no home study is required, will make the average time spent in study lower in that grade than in any other. Another peculiairty is that, in the grading of students in the last year, only those whose work is completed through the requirements of the 12-B grade are classified as 12-A's. This results in a number being graded as 12-B's who are attempting to graduate by carrying extra studies, and this will make the average 12-B work appear heavier than the rest.

The tabulated results of the student reports, with a few conclusions, follow:

TIME SPENT IN STUDY.

Grade.	Replies.	Av. Study Hrs. per School Day.	Av. Rec. Hrs. per Week.	Av. Minutes per Lesson.
12A	79	2.91	17.33	50.4
12B	102	3.21	19.11	54.2
11A	146	2.73	18.47	44.3
11B	163	2.69	18.02	44.7
10A	198	2.42	17.94	40.5
10B	190	2.47	18.18	40.8
9A	320	2.67	18.01	44.5
9B	233	2.37	17.89	39.8
Total	1431	2.65	18.11	44.8

On this chart we have the number of replies by grades, the average number of recitation hours per week, the average time spent in preparation of lessons per school day, and the average time spent per lesson. We find that while some may spend almost no time on their studies, and others from five to six hours daily, the pupil of average ability, carrying the average amount of work, is getting his lessons, at least to a passing grade, with a total of a little over 2½ hours of concentrated effort. This averages about 45 minutes to a lesson. Some lessons are learned in less time than this, and others take a little longer. This certainly is not evidence of much over-study. Please keep in mind that the average amount of work carried is about 18

hours per week of between three and four recitations per day, and the average time spent in study is about 2 hours and 39 minutes.

COMPARISON OF TIME SPENT ON CERTAIN SUBJECTS.

Subject.	9th Gr.	10th Gr.	11th Gr.	12th Gr.	Average.
English	31.4	33.1	35.2	43.0	35.6
History	49.6	41.3	43.0	55.1	47.2
Mathematics	51.2	45.0	44.05	61.3	50.4
Modern Languages	51.9	47.4	62.1	61.9	55.8
Classical Languages	40.7	52.2	44.9	72.4	52.1
Science	...	38.1	40.6	62.1	46.9

It may be of some interest to compare the amount of time spent upon certain subjects which are supposed to take up the major part of the student's time. Commercial studies and those not running through the grades are purposely omitted. This chart does not represent the actual average of the time spent by all pupils reporting in these subjects. In order to obtain a result that would show the amount of time spent by the more reliable students who were doing satisfactory work, each grade principal was asked to select from the reports a considerable number that in her judgment represented the work of the grade and whose reports might be relied upon. It is from these reports that this table is made. The least time spent is in English. History and science run about even, mathematics and the languages run very closely together for the first place in the point of time. The amount of time spent in Modern Languages in the 11th and 12th grades appears large on account of an abnormal local condition. By eliminating this feature the average is reduced to 51.8. Latin and Greek still claim the honors for the length of time in the preparation of lessons. The almost uniform increase through the grades is noticeable with the exceptions in the ninth grade, where a considerable amount of time is evidently wasted in not yet knowing how to study or ecomomize time. Some questions naturally arise as: Have all subjects an equal right to the pupil's time? Have language and mathematics the right to demand so much more than science and history?

We all seem to have the idea that "when we were young" we worked much harder than the present generation, just as the present senior in high school thinks that the ninth grade is to-day much younger and smaller than when *he* entered high school. When I was a student in the Ceneral High School, Mr. Bliss, now of the Detroit University School, made a very exhaustive investigation along this line of overwork. From his report I have been able to compare, in a way, the time spent in study and the total time spent in school and out.

TABLE OF COMPARISON.

	Hours Spent in Study.		Total Time Spent on School Work.	
	1887.	1906.	1887.	1906.
9B	3.11	2.37	6.36	5.95
9A	2.82	2.67	6.02	6.27
10B	3.08	2.47	6.26	6.10
10A	3.09	2.42	6.37	6.01
11B	2.01	2.69	5.53	6.29
11A	2.90	2.73	6.15	6.42
12B	2.82	3.21	6.07	7.03
12A	2.56	2.91	5.72	6.37
Average	2.79	2.65	6.06	6.30

The curriculum of that time was quite different from the present. There was very little laboratory or library work done. All subjects were recited every day. It was practically all text-book work which would demand more time in study than would our present methods. However, there is not a great amount of difference or as much as I was expecting to find. You will notice that in 1887 the ninth grade was studying longer than in 1906, while in the twelfth grade we are now working the longer, which is, possibly, a little better arrangement. The total averages are not so far apart after all—a matter of 8 minutes per day on study and 15 minutes on total school work.

PERCENTAGE OF OVER-STUDY.

	Over 3½ Hrs.		Over 4 Hrs.		Over 4½ Hrs.		Over 5 Hrs.	
Grade.	No.	Percent.	No.	Percent.	No.	Percent.	No.	Percent.
12A	23	29.11	10	1.27	4	.51	2	.25
12B	45	44.11	19	1.86	10	.98	7	.68
11A	40	27.39	24	1.64	3	.21	0	.00
11B	38	23.31	19	1.16	6	.36	4	.25
10A	22	11.11	8	4.04	5	.25	3	.15
10B	30	15.90	9	4.74	6	.32	1	.05
9A	60	18.75	27	8.44	17	.53	13	.41
9B	21	09.01	12	5.15	8	.34	6	.26
Total	279	19.49	128	8.94	59	.40	36	.25

Is there over-study in the high school? There are always a few plodding, conscientious pupils who are naturally so constituted that they can not help over-working. Some may not know how to use their time to advantage, but with all possible explanations there are very few who are studying more than is good for them. Those studying more than the average of 2.65 hours per day, I have grouped as follows: over 3½ hours, over 4; over 4½, and over 5 hours per day. Only 19 per cent are spending over 3½ hours. Not quite 9 per cent over 4 hours, and only .4 of 1 per cent over 4½. The .25 of 1 per cent studying over 5 hours per day does not indicate that very many students are suffering from the excessive demands of the school. Practically all of these individual cases when inquired into are explained by an attempt to carry too much work to make up for lost time, or by a lack of knowing how to use time in study.

To obtain more completely the student's point of view, questions were asked of the eleventh and twelfth grade pupils as follows:

1. Are you regularly employed in the afternoon or evening? If so, how many hours are thus spent each day?

2. Are you studying music or any other subject regularly outside of school? If so, how much time is actually required each day?

3. Do you consider the course of study as planned for graduation burdensome to the pupil who does his work faithfully?

STUDENTS APPROVING COURSE.

Grade.	No.	Percent.	Number Working.	Av. Hrs.
12A	74	93.7	23	3.5
12B	93	91.1	29	2.0
11A	121	82.8	30	2.4
11B	131	80.4	39	2.0
Total	419	85.5	121 or	28.8%

You will observe that the students longest in school approve more fully than those who still have a year ahead of them. Of the eleventh and twelfth grades 85.5 per cent approve the course of study. Of these there are 121 or 28.8 per cent who are regularly taking outside lessons or working an average of over two hours each day who do not feel that the work is burdensome. The individual answers to the last question are rather interesting. Many expressed their emphatic views by printing NO in large letters, underlined, or with several exclamation points after it. Such expressions as "Not a bit," "Decidedly No," "Not for me," "Of course not," were frequent. In talking with many individual students I have found that the general idea prevails that very little hard studying is done.

STUDENTS THINKING COURSE BURDENSOME.

Grade.	Weak. No.	Rec.	St'y.	Over-Ambitious. No.	Rec.	Wrk.	St'y.	Slow. No.	Rec.	St'y.	Lazy. No.	Rec.	St'y.
12A	..	...	..	..	...	..	..	5	16.8	3.3	..	...	..
12B	6	21.2	3.4	1	18.0	3.0	3.2	1	19.0	3.9	1	17.0	1.7
11A	11	20.5	2.9	4	20.0	2.0	2.9	6	16.5	3.9	4	16.0	1.5
11B	7	21.1	3.3	9	17.0	2.4	2.6	10	16.1	3.3	6	16.6	1.8
Total	24	21.3	3.2	14	18.3	2.5	2.9	22	17.1	3.6	11	16.5	1.6

Fourteen and one-half per cent replied that they did feel that the requirements were too heavy. These naturally fall into four classes as follows: (1) The weak, or those who have failed and are attempting to carry one or two extra studies to make up for lost time as shown by the table: (2) The over-ambitious or those who attempt to carry full work in school or 18.3 hours of recitation, and at the same time take up music or some outside study, or regular employment for an average of two and one-half hours each day and then study for about

three hours: (3) The slow or plodding student who must study much longer than the average student while carrying less work; and (4) The lazy student who carries as few subjects as the law allows and who studies as little as possible on them, as the table shows spending a little over 1½ hours per day in study. It is not difficult to understand why each of these students answered the question in the affirmative. When interviewed personally no student could justify himself on second thought, for having handed in this answer. We may therefore conclude that the students do not think themselves greatly abused.

The high school life is becoming a very prominent factor in the education of the high school pupil. If we look into the individual cases of over-work, we find that very often the burden comes from the many organizations or social influences about the school rather than from the course of study. From the fact that he is enrolled in the school, the pupil is confronted with a great variety of influences which bear upon him with a pressure that proves disastrous to some and to those who survive a most valuable school of experience.

Upon entering the school the poor ninth grader is met with beautifully decorated portions of the blackboard inviting him to join or attend as the case may be some of the following attractions: Athletics according to season—football, basketball, hockey, baseball and track. Even though he may not take active part in these sports, if he catches the high school spirit, learns the yell, and wears the proper insignia on his cap, he feels in duty bound to witness the afternoon practice and attend all the games. If musically inclined here is his opportunity. The Orchestra, Boys' Glee Club, Girls' Glee Club, Choral Society, Boys' Mandolin Club, and Girls' Mandolin Club, are all seeking new members. Possibly he may be enticed more by the announcement of a Dramatic Club, Debating Society, or the solicitations to contribute to the monthly paper or annual of the school. If he is of a certain type, not difficult to describe, he is soon made acquainted with the fact that there are several high school fraternities that would like a considerable portion of his time. This poor ,bewildered youth may possibly have had some associations with his church, Sunday school or neighborhood that demanded a little of his time before entering high school, but now! What will he do with it all? The natural impulse is to take it all in if possible and perchance to do some studying on the side. For the first time in his life he is master of much of his own time. He is now expected to do most of his studying at home. How to use time to advantage he has never learned. Few attempt to solve the problem but rather follow impulse and become involved in the whirlpool of too many temptations. Let the teacher go down-town on a pleasant afternoon and many familiar faces will greet him with a conscious smile, or if he attend the theater or social gathering during the week he receives many a request not to call on somebody in recitation the next day. Here is the usual cause of over-pressure! The

schools can do much and some of them are doing a great deal, through faculty supervision of all departments of school life, to guide the pupil through this maze of attractions, and to give him the benefits to be found in the various organizations without allowing them to interfere with his studies. The many temptations outside of the school that interfere with the student's work are beyond our control and their solution lies wholly with the parent. Do not think that I am objecting to the existence of all these evidences of student activity; on the contrary I am very much in favor of them all when under the proper faculty control. If it is the duty of the high school to prepare the student for actual life, he should not be sheltered too long from the many demands that life and society are making upon us all. He should realize that he must choose wisely, distinguish between duty and pleasure, and judge well of the best use of his time. If the student can learn by his high school experience how much of his time he can allow from business to society, athletics or other attractions without a sacrifice of success in all lines, he will have learned a most valuable lesson.

The result of this investigation is sufficiently accurate and complete to show that the average student is not spending the time upon his studies that perhaps we or his parents thought he was. Very few have been found who are at their work longer than is good for their health or proper development. By comparing the time spent on various subjects we can not help wondering whether the students are spending the greater portions of their time in the subjects which will give the greater return for the actual time spent. We are convinced of the fact that boys and girls are much the same today as they were a generation ago, and that they are dividing their time just about as they always have done. The average student does not feel himself burdened with work, and he is fully enjoying the various social or athletic opportunities without allowing them to interfere seriously with his scholarly standing. Overpressure, then, as charged, does not exist in the high school. It will appear to most teachers that more could be demanded of the average student to his advantage because the life and demands of the school should require an exerting of will power and a putting forth of effort upon his part if he is to be prepared to do battle with the world. His experience before graduation should give him some idea of the pressure that he must inevitably face and under which he must eventually stand or fall.

CONFERENCES

CLASSICAL CONFERENCE

IS LATIN HOLDING ITS OWN IN OUR HIGH SCHOOLS?

PRINCIPAL GEORGE R. SWAIN, BAY CITY EASTERN HIGH SCHOOL.

Something over a year ago I found that in the Bay City Eastern High School the enrollment in Latin classes, especially in Cicero and Vilgil, had for some time been diminishing. After speaking of the matter to several other persons interested in school work, I began to suspect that the condition was not local, but probably true of the state as a whole and perhaps true of neighboring states as well. Happening "sive casu sive consilio deorum immortalium" to mention the matter to Professor Kelsey, the chairman of the Classical Conference a year ago, I was straightway requested to look the matter up and report this year.

Knowing that a conclusion based on surmise, conjecture and inference would justly be relegated to the limbo of Cassandra's prophesies, I have fortified my position (which will be formally stated later on) with defenses of statistics, which, though markedly defective, will yet give a fair basis for reasonably accurate generalizations.

The inquiry, at first limited to our own state, was afterward broadened to include the group of north central states—Minnesota, Wisconsin, Iowa, Illinois, Indiana and Ohio. Return postal cards were sent to the leading schools with a blank on the return card asking for statistics giving total enrollment, total number studying Latin, number of graduates, and number of graduates having four years Latin for each of the five school years just passed.

Much difficulty has been encountered in getting the desired data, for in many cases high school records have through accident been destroyed, are sadly incomplete, or are in such form that answers to my questions could be obtained only by arduous research in dusty pigeonholes. In consequence, to many cards I received no answer, and in numerous other cases only incomplete replies. My hearty thanks are hereby given to the people who did take the trouble to send complete statistics. The following tables show the results of my investigation:

TABLE I—MINNESOTA.

Cards sent, 45; complete replies, 17; incomplete replies, 9; total, 26.
Complete replies from the following schools: Albert Lea, Alexandria, Anoka, Cloquet, Detroit, Duluth Central, Faribault, Fergus Falls, Glencoe, Hastings, Little Falls, New Ulm, Owatonna, Red Wing, Rochester, St. Paul Central, Stillwater, Winona.

Year.	Enrollment.	Latin.	% Latin.	Graduates.	4 Yrs. Latin.	% 4 Yrs.
1900-1901	3800	1733	45.6	431	208	48.2
1901-1902	3986	1924	48.2	543	245	45.1
1902-1903	4254	2063	48.4	599	254	42.4
1903-1904	4651	2182	46.9	608	245	40.3
1904-1905	4991	2288	45.8	625	237	37.9

This indicates that the number taking Latin is practically the same per cent as five years ago, but shows a steady decline in the per cent taking four years of Latin.

TABLE II—WISCONSIN.

Cards sent, 45; complete replies, 12; incomplete replies, 8; total, 20.
Complete replies from the following: Beaver Dam, Green Bay, Janesville, La Crosse, Menominee, Milwaukee South Division, Milwaukee West Division, Ripon, Sheboygan, Washburn, Waukesha, Waupun.

Year.	Enrollment.	Latin.	% Latin.	Graduates.	4 Yrs. Latin.	% 4 Yrs.
1900-1901	3003	1161	38.6	313	134	42.8
1901-1902	3044	1101	36.1	356	150	42.1
1902-1903	3288	1024	31.1	361	149	41.2
1903-1904	3200	960	30.3	412	141	34.2
1904-1905	3401	927	27.2	420	115	27.3

*Paper and discussions at the classical conference, March 29.

This shows a decline in the number taking Latin of over 11 per cent, and a decline in the number taking four years Latin from 42.8 per cent to 27.3.

These statistics from Minnesota and Wisconsin may, I think, be considered representative, including as they do both large and small schools.

TABLE III—IOWA.

Cards sent, 46; complete replies, 9; incomplete replies, 9; total, 18.
Complete replies from the following: Boone, Clinton, Dubuque, Hampton, Knoxville, Lyons, Maquoketa, Missouri Valley, Newton.

Year.	Enrollment.	Latin.	% Latin.	Graduates.	4 Yrs. Latin.	% 4 Yrs. Latin.
1900-1901	1623	994	61.2	230	110	47.9
1901-1902	1731	1053	60.8	217	110	50.6
1902-1903	1834	1083	59.0	245	129	52.6
1903-1904	1877	1115	59.4	216	117	54.1
1904-1905	2013	1121	55.6	208	109	52.4

This shows a falling off in the per cent taking Latin, while the number taking four years Latin has on the whole increased.

TABLE IV—ILLINOIS.

Cards sent, 50; complete replies, 6; incomplete replies, 10; total, 16.
Complete replies from the following: Decatur, Elgin, Evanston, Freeport, Kewanee, Streator Township.

Year.	Enrollment.	Latin.	% Latin.	Graduates.	4 Yrs. Latin.	% 4 Yrs. Latin.
1900-1901	2517	1102	43.7	320	110	34.3
1901-1902	2406	1105	45.9	291	85	29.2
1902-1903	2357	1108	47.0	304	86	28.2
1903-1904	2432	1093	44.9	256	88	34.3
1904-1905	2565	1178	45.9	315	98	31.1

I do not consider the statistics from Iowa and Illinois extensive enough to make any conclusion based upon them very reliable. I have been unable to secure any figures from the Chicago high schools. Principal Boyer, of the Bloomington high school, writes that the number taking Latin is decreasing each year.

TABLE V—INDIANA.

Cards sent, 50; complete replies, 10; incomplete replies, 3; total, 13.
Complete replies from the following: Columbus, Hammond, Indianapolis (Shortridge), Michigan City, Mount Vernon, Rockport, Tipton, Valparaiso, Washington, Winchester.

Year.	Enrollment.	Latin.	% Latin.	Graduates.	4 Yrs. Latin.	% 4 Yrs. Latin.
1900-1901	2573	1879	73.0	264	117	44.3
1901-1902	2549	1852	72.6	313	94	40.0
1902-1903	2686	1964	73.1	277	70	28.5
1903-1904	2740	1975	72.0	335	109	32.5
1904-1905	3088	1978	64.0	303	107	35.3

Here although the number of graduates having four years' Latin has increased for three years, still the last year shows a marked decrease in the total per cent taking Latin; this augurs ill for the future. Miss Campbell, teacher of Latin at South Bend, says the number taking Latin is decreasing in that school.

TABLE VI—OHIO.

Cards sent, 60; complete replies, 15; incomplete replies, 7; total, 22.
Complete replies from the following: Ashtabula, Canton, Cincinnati (Woodward), Cleveland East, Columbus North, East Liverpool, Elyria, Findlay, Ironton, Newark, Sandusky, Springfield, Steubenville, Tiffin, Xenia.

Year.	Enrollment.	Latin.	% Latin.	Graduates.	4 Yrs. Latin.	% 4 Yrs. Latin.
1900-1901	5706	3309	57.9	654	433	66.2
1901-1902	5884	3457	58.7	637	401	62.8
1902-1903	6183	3575	57.8	695	385	55.3
1903-1904	6317	3595	56.9	643	376	58.4
1904-1905	6854	4287	62.5	754	434	57.5

These statistics are probably representative enough that fuller reports would not change the per cents materially. It is to be noted that the per cent of pupils studying Latin is greater in 1904-1905 than in any previous year.

So much for our neighbors. In our own state I attempted to trace the vicissitudes of Latin for ten years instead of five. In place of reply postal cards, letters with a blank and return addressed stamped envelope were sent. As was to be expected, the difficulty in securing

data was more than doubled in trying to cover ten years instead of five. The results are given in the following table. In this table, after the column giving the per cent studying Latin is inserted a column giving the corresponding per cent for all the high schools of the United States according to the latest report of the Commissioner of Education, Dr. Harris:

TABLE VII—MICHIGAN.

Letters sent, 51; complete replies, 15; complete for last five years, 19; incomplete, 10; total, 29.

Complete replies from Ann Arbor, Battle Creek, Bay City E. S., Detroit Central, Detroit Eastern, Flint, Iron Mountain, Kalamazoo, Marshall, Monroe, Muskegon, Port Huron, Saginaw E. S., Saginaw W. S., St. Joseph.

Complete replies for last five years: Charlotte, Jackson W. S., Manistee, Ypsilanti.

Year.	Enrollment.	Latin.	% Latin.	% in U. S.	Graduates.	4 Yrs. Latin.	% 4 Yrs. Latin.
1895-1896	5648	2679	47.4	46.2	546	205	37.5
1896-1897	5927	2895	48.8	48.4	564	187	33.1
1897-1898	6455	3144	48.7	49.7	612	280	45.7
1898-1899	6489	2906	44.7	50.4	673	226	33.5
1899-1900	6597	2894	43.8	50.6	616	237	38.4
1900-1901	7407	3206	43.2	50.6	791	358	45.2
1901-1902	7639	3080	40.3	50.1	795	289	36.3
1902-1903	7699	2990	38.8	50.3	831	286	34.4
1903-1904	7898	2989	37.8	...	899	237	26.2
1904-1905	8899	3326	37.2	...	908	241	26.5

The apparently heavy increase in enrollment for the year 1900-1901 is in part due to the introduction at that point of the statistics from Charlotte, Jackson W. S., Manistee, and Ypsilanti.

Of all the schools mentioned above, Flint, Iron Mountain, Monroe, Port Huron, Manistee and Jackson W. S., only show an increase in the number of pupils taking Latin during the last two or three years; the falling off in the other schools has more than balanced the gain here. It is noticeable, however, that the decrease for all the schools is less the last year than for some years preceding, while there is a slight gain in the per cent of graduates having four years Latin.

The table shows that for the schools under consideration the per cent of pupils taking Latin has fallen from 48.8 in 1896-1897, to 37.2 in 1904-1905, and that the per cent of graduates having four years Latin has fallen from 45.7 in 1897-1898, to 26.5 in 1904-1905.

The following table shows the results obtained by combining the statistics for the seven states investigated:

TABLE VIII.

Minnesota, Wisconsin, Iowa, Illinois, Indiana, Ohio and Michigan.

Year.	Enrollment.	Latin.	% Latin.	% in U. S.	Graduates.	4 Yrs. Latin.	% 4 Yrs. Latin.
1900-1901	26629	13384	50.2	50.6	3003	1470	48.9
1901-1902	27239	13572	49.7	50.1	3152	1374	43.5
1902-1903	28301	13807	48.7	50.3	3312	1368	41.3
1903-1904	29115	13909	47.7	...	3369	1313	38.9
1904-1905	31808	15105	47.4	...	3533	1341	37.9

This shows a much greater decrease proportionally in the number of pupils having four years' Latin than in the total number taking Latin.

The next table is inserted for the purpose of showing at a glance the per cent of pupils taking Latin in the schools investigated in the seven states already mentioned:

TABLE IX.

Percentages of Pupils Taking Latin.

Year.	Minn.	Wis.	Iowa.	Ill.	Ind.	Ohio.	Mich.	Ave.	% in U. S.
1900-1901	45.6	38.6	61.2	43.7	73.0	57.9	43.2	50.2	50.6
1901-1902	48.2	36.1	60.8	45.9	72.6	58.7	40.3	49.7	50.1
1902-1903	48.4	31.1	59.0	47.0	73.1	57.8	38.8	48.7	50.3
1903-1904	46.9	30.0	59.4	44.9	72.0	56.9	37.8	47.7	...
1904-1905	45.8	27.2	55.6	45.9	64.0	62.5	37.2	47.4	...

This shows an increase in the per cent taking Latin in Ohio, but a decrease in all the others, the loss apparently being greatest in Wisconsin.

Lastly, the following table exhibits a comparison of the percentage of graduates having four years' Latin in all the schools reporting full statistics:

TABLE X.

Percent. of Graduates with Four Years Latin.

Year.	Minn.	Wis.	Iowa.	Ill.	Ind.	Ohio.	Mich.	Average.
1900-1901	48.2	42.8	47.9	34.3	44.3	66.2	45.2	48.9
1901-1902	45.1	42.1	50.6	29.2	30.0	62.9	36.3	43.5
1902-1903	42.4	41.2	52.6	28.2	28.5	55.3	34.4	41.3
1903-1904	40.3	34.2	54.1	34.3	32.5	58.4	26.2	38.9
1904-1905	37.9	27.3	52.4	31.1	35.3	57.5	26.5	37.9

This shows that there has been a heavier decrease in the per cent of graduates having four years' Latin in Michigan than in any other state.

In view of the statistics tabulated, I consider that the following propositions are rendered highly probable:

1st. There has been a slight falling off in the per cent of pupils taking Latin in these seven states.

2nd. The decrease in Michigan has been about twice the average decrease.

3rd. During the same period (the preceding five years) there has been a marked falling off in the per cent of pupils graduating with four years Latin.

4th. In this falling off, the decrease in Michigan has been markedly greater than in any other state of the group.

So far as the decrease in the total number taking Latin is concerned, two things have perhaps had something to do with it, although there are doubtless others factors. First, in some of the larger schools at least the increase in enrollment has been in part due to the better facilities offered in obtaining a business education, and this has at-

tracted some pupils who otherwise would not have entered high school at all. Second, with the large increase in enrollment, we are getting more and more pupils (I suspect) from families of little academic culture where parents see little good in any form of education that does not straightway facilitate the speedy capture of the almighty dollar.

With reference to the smaller number taking four years Latin, the situation is somewhat puzzling. Three things at least have contributed to the present unsatisfactory state of affairs: First, Latin is no longer required by the University of Michigan for the degree most desired by many prospective college students; second, the wider range of electives now offered in the larger high schools; third, a disinclination on the part of many, or of some at least, of the present class of students in high schools for earnest, steady, sustained hard work in any direction, let alone four years of it. In my opinion this last is to be in part explained by the amount of social frivolity indulged in by would-be society young men and ladies, who, had they wiser parents, would be simply high school girls and boys.

In any case, the state of affairs is one that should no longer be ignored by friends of Latin, in school or out.

In conclusion, with respect to Michigan, as some indication that conditions may improve, come the words of Principals Nye, of Traverse City, and Marsh, of Jackson W. S., who report a marked increase in Latin enrollment, and the cheerful message of Principal Wade, of Flint, who declares that he fully expects to graduate a class in 1908, one-half of whom will have had four years' Latin.

DISCUSSION OF PRINCIPAL SWAIN'S PAPER.

BY PRINCIPAL DAVID MACKENZIE, DETROIT CENTRAL HIGH SCHOOL

I.

Though acceding to Professor Kelsey's request that I discuss this paper, I do not feel that I have much of value to give, either in the way of diagnosis or prescription; for I must speak not as a teacher of Latin, and, therefore, not with the authority of a close observer and a specialist, but from the administrative standpoint, which, however, may afford a clearer judgment because it is more distant and less disturbed.

The last decade undoubtedly shows a marked decrease in the number of pupils studying Latin in high schools both in Michigan and throughout the United States; still I do not regard this in the light of senile decay, but rather as a readjustment and natural change characteristic of all healthful maturity compared with the rapid and irregular growth of youth. There is then nothing alarming or appalling in the statistics of the paper. The decrease is in part the result of radical

changes in industrial and social conditions—and these always have been and always will be the determining factors in educational ideals—and in part the result of unwise and unpedagogical methods of instruction.

The first general fact that I would present for your consideration is the remarkable growth of high schools during the present generation, and some of the effects that have resulted from this growth in our efforts to adjust the curriculum to the needs of the pupils. In 1860 there were but 40 public high schools in the United States. In 1880 this number had increased to 800, and in 1900 to over 6,000. At the present time the enrollment compared with the population is greater than it is in any other country, exceeding even that of Prussia by one-half of one per cent. The high school therefore, has been passing through a great formative epoch, which has shown many fluctuations and will continue to show such, probably, before it attains to a natural and steady growth.

The high school now is a distinct unit in the educational organism. It is neither a mere extension of the elementary school, nor a preparatory annex of the college. Although occupying an intermediate place in the educational triad between the elementary school and the college, it has a distinct aim and purpose of its own, and must have freedom and opportunity to grow and to develop in accordance with the new demands of the times. In recent years it has shown two prominent phases in its development, each of which leads as easily and directly to social and industrial efficiency as did the older academic system of instruction. I do not intend to enter here upon a defense of manual training and commercial studies, but wish merely to state what is evident to all unbiased secondary teachers—that these two departments of progressive high schools offer to a large proportion of pupils a more attractive and a more rational mode of instruction and training than does the purely academic program. The introduction and rapid extension of these subjects into even the smaller high schools and the phenomenal growth of their counterparts in the schools of technology and of commerce in all of the larger colleges and universities has of itself been an all-important factor in determining the rapid decrease in the number of pupils who study Latin in our secondary schools. And this, it seems to me, should suggest the real question that should occupy our attention. It is not how shall we increase the number of pupils in Latin, for this is comparatively easy since it rests almost entirely with ourselves, so great is our influence over pupils in this respect; but rather—and this is much more difficult—how are we to determine who among our pupils will be most benefited and helped by the study of Latin?

But there is another factor in the growth of the high school that has helped to decrease the number of Latin pupils, to which I would call your attention. For many years the proportion of girls in the high school was increasing over that of the boys. But the great indus-

trial development of the present decade and the corresponding enlargement and adjustment of the curriculum has brought about a great change in this respect. In the Detroit Central High School in 1900 the percentage of boys in the graduating class was only 31. In 1905 this had increased to 61, and in our present class the percentage of boys almost equals that of the girls. Now this has been an important factor in causing a proportionate decrease in the number of Latin pupils. For when the number of girls was so much greater than that of the boys, the proportion of pupils studying Latin was greater, because a larger number of girls than boys elect Latin, since girls are naturally more conservative than are boys, are much more inclined to follow tradition and custom, and especially are more willing to accept without question the judgment and wishes of parents and teachers.

The second general fact that I would raise for consideration as affecting the number of pupils now studying Latin is the influence of collegiate affiliation and control. This relationship has, I think we must all admit, been helpful to the high school. It has proved a powerful stimulus in raising standards of scholarship in all schools, in strengthening and developing the weaker schools, and in establishing new ones everywhere. Yet the high school has now become quite a lusty youth, and may be advantageously permitted to work out its own development, uncontrolled, directly or indirectly, by collegiate standards and requirements. The removal of Latin from the entrance requirements of most colleges, which is to be commended as a recognition of the right of the school and the student to this larger freedom has, of course, lessened the number of college preparatory students who are taking Latin. But by what pedagogical right does a college impose such conditions indiscriminately on all who wish to enter its halls? The same results would appear also in the case of mathematics and physics, were the irrational restrictions in these subjects removed.

I do not agree with the speaker in his declaration that the chief cause of the decline is, perhaps, because pupils no longer are willing to study with the same intensity as formerly and, therefore, finding Latin too difficult, choose easier subjects. My conviction is that pupils not only study as much as they formerly did, but with much more intelligence and with better results. In my day the college preparatory curriculum included scarcely anything but Greek, Latin and mathematics, in which there were daily recitations. I am confident, nevertheless, that the work done in mathematics in the Central High School by the present generation is superior in quantity and quality to that done by my generation, while the work that is done today in history, English, and science is entirely new and was not even attempted twenty years ago. Notwithstanding all this increase in other studies, I fail to see any inferiority in the classical work of today. Finally, from an investigation that has been made in our school within the past few weeks, we learn that the average time spent by pupils today compares favor-

ably with that of the pupils of fifteen years ago, when a similar investigation was made. I do believe, however, that the fact that the classical preparatory requirements are heavier than they should be and are greater than those in English, history, and some of the sciences turns many from the pursuit of Latin and Greek. The average pupil today has a keen appreciation of values considered from his viewpoint, and he does not fail to observe, when he makes out his program of studies, that for two units of credit he must give 20 hours of recitation in Latin, 25 in Greek, and only 16 in other subjects. Another baneful effect of college domination over the study of Latin in the high schools is to be found in that unpedagogical principle which was given expression in the "Report of the Committee of Ten," viz., that "fitting for college and for life are the same." This theory does not permit us to recognize the fundamental differences that exist in the mentality of pupils and in their aims, and practically forces us to teach Latin to all pupils in accordance with the methods and the requirements prescribed by the colleges. The majority of the pupils in our high schools have no intention of ever going to college even although they do study Latin; and they should have the opportunity of getting from this study whatever values it may possess for them. To secure such results requires that the subject should be approached in many different ways. Surely no practical teacher will insist that the same method should be followed whether a pupil is to study Latin one year, two years, or four years, or even for additional years in college. I hold that for some pupils there may be great value even in one year of Latin; but a pupil is apt to question the truth of this and will certainly hesitate to undertake it, when he learns that the college authorities deny that it has any value, as they certainly imply when they refuse to give any credit for less than two years' work. I find upon questioning pupils as to the reason of their choosing Latin that many of them have been persuaded to do so by parents and elementary school teachers who have had but one year of Latin, but have found that that one year has been of great value to them.

It is my belief that the generally prescribed method of teaching Latin to high school pupils is unpedagogical and, therefore, is unsatisfying to them. The child's mind is not logical, critical, and intensive, which is the assumption of the method in general use, but it is perceptive, concrete, and above all creative. Undoubtedly the rudimental work of first year Latin with a wide-awake and sympathetic teacher is valuable in many ways, but it necessarily grows uninteresting and irksome, especially when it is overweighted with innumerable disconnected and almost meaningless sentences in prose composition, because it confines him to parts instead of larger wholes, deprives him of all initiative, and is devoid of any content that illumes his vision and interprets for him his life.

Another important defect in our method is to be found in the

almost complete subordination of literature to language. This, however, practice is to impose on our pupils the critical and intensive reading of a few masterpieces instead of encouraging a wide reading for the cultivation of taste and literary appreciation. To return to our Latin, we read Cæsar and Cicero, Ovid and Virgil largely for the opportunity they afford—at least so it must seem to the pupil—of illustrating syntactical principles. And yet Cæsar was a world conqueror, Cicero a great orator, jurist, and statesman, Ovid and Virgil most delightful poets and interpreters of the life and thought that Rome and the Roman people embodied. That Latin is regarded by pupils as only a "grind" and as contributing so little to the enrichment of their mental and spiritual life is the fault of our method and of the insignificant results that the teacher himself too often has derived from his Latin reading and study in college. He can not give what he himself has not gained, and so continues to teach others as he himself was taught. He must through his advanced collegiate studies have so entered into the spirit of Latin life and thought that he can re-create in his classroom the old Roman life and atmosphere and, banishing all mechanical habits, vivify his work and reveal to his pupils the message which Rome still has for the world.

In conclusion. If Latin is declining in popularity among our pupils, the remedy lies largely in ourselves, as teachers and school officers. Pupils are ever ready to accept the opinion of a teacher whom they respect in the matter of the selection of their studies. Personally I have found it an easy matter to influence any proportion of a class to include Latin among their optional studies. As principal I have made it a practice each term to talk to the entering classes upon the value of different studies, and have been forced to speak with the greatest care in order to prevent what seems to me is too large a proportion of the pupils from electing Latin. If this be the case—and I do not believe my experience in this respect is peculiar—surely when they do not continue the subject after beginning it, it must be because they do not feel that they are getting value received. The fact that so many pupils at the present time discontinue their Latin after completing two years of it is, of course, because so many of our boys are preparing for the technical courses in college, and must meet the varied requirements of these schools. But I am sure the commonly prescribed work of the second year is responsible for much of this. After a boy has labored with all the difficulties and the uninteresting content of Cæsar, his brief and hurried introduction to the new and in some respects greater difficulties of Cicero very naturally convinces him that he has no desire for a further acquaintance with Latin literature.

If, then, we really believe that Latin is of value to all who desire a wide outlook upon life and direct participation in the heritage of the past, and desire that as many as possible of our pupils should have this opportunity, let us, first of all, eliminate the more obvious errors

in our methods and courses of study, and let us also remember that although Latin has been for long the great highway upon which students have traveled, yet today it is not the only road, and for many is not the most direct road, to a life of the widest usefulness.

II.

BY PROFESSOR BENJAMIN L. D'OOGE, MICHIGAN STATE NORMAL COLLEGE

I think we should be grateful to Mr. Swain for having gone to the trouble and expense of gathering these statistics. At the same time there is cause for regret that his labor has been so largely in vain, owing to the failure in getting replies to his letters. This, while due to no fault of his own, must of necessity detract from the value of his inferences. In fact, the number of complete replies received from any one state is so small that it is impossible to generalize from them or come to any reliable conclusion. Still my own observation and inquiries lead me to the conviction that the conclusions are in the main correct in so far as they show a decrease in the number of those studying Latin and Greek, and I am further convinced that in Michigan the conditions are much worse than his statistics show. A leading publisher, who makes a business of keeping posted on such matters, told me recently that Michigan, formerly the leading state in classics in the Middle West, has now fallen below the average, and in a list of twenty-five states of the Middle West and South would stand about the fifteenth in rank. I do not think this is exaggerated.

This discussion ought to bear practical fruit in making teachers of the classics in Michigan fully alive to the grave peril in which they stand and lead to an aggressive awakening. The remedy for these conditions lies largely in their hands. In my judgment three lines of action are open and should be followed: First, personal work with students, in directing their election of studies; second, better preparation of teachers and more effective teaching; third, better facilities for teaching in the way of books, maps, and illustrative material. In these ways better results can be shown and greater interest in the classics aroused.

It must be frankly stated that the evil times in Michigan are due primarily to the change in the university requirements for admission, and I do not believe we can hope for a change for the better as long as the requirements remain as they are. It seems to me that the time is ripe for reopening the whole question of college requirements in this state. The secondary school people were satisfied with the old requirements. The attack upon them came not from them but from forces in the university. If the university will lead the way back to the old requirements, the secondary school will gladly follow.

III.

BY PRINCIPAL F. L. BLISS, DETROIT UNIVERSITY SCHOOL

I am placed at a disadvantage in attempting to discuss a paper which I have not heard, but the very careful syllabus of the paper given me in advance will serve as a good guide.

I will make an attempt to answer in particular the question as to why facts are as they are. It is perfectly clear from the statistics presented this morning that there has been, in a large number of schools in the North Central States, a falling off in the number of students pursuing Latin, and, especially, a much larger falling off proportionately in the number of students pursuing the four years' course in Latin.

This fact must have some cause. It seems to me that the explanation is a very simple one. It may be well to state in advance that to my mind it is clear that the colleges are solely responsible for this state of affairs.

The thing that I regret this afternoon is that we have not with us all trustees and the faculties of the colleges in every state, from which statistics have been given. I think some of them would be converted, and would realize that it is possible for the colleges to set a standard to which all schools can come.

One of the reasons that Latin is not studied so much as it was, is that it is a difficult study; it involves hard work. The average boy follows the line of least resistance. The teacher can do much in urging him on, but as a general thing if he has not a liking for Latin he will not study it very long.

Another thing that has contributed somewhat to the falling off in the number of Latin students in the schools has been, perhaps, the great advance in standards of scholarship. We have been unconsciously demanding of students in Latin a little more each year than we demanded the year before. Better results are secured, but at the cost of driving away thousands at the end of the first or the second year who ought not to go.

An exaggerated idea of the importance of classical scholarship, and especially of its philological aspects, often becomes the most dangerous for the spread of classical culture.

There are other causes contributing to the general results. They have been well indicated in Mr. MacKenzie's remarks this morning.

But if we are to seek the real cause of the change, we must find it in the action recently taken by many institutions in the requirements for the A. B. degree. Classical study has thus been cruelly wounded in the house of its friends. No more fatal blow to real scholarship was ever struck than the act of many institutions in cheapening this degree by granting it—the degree which has always stood for solid attainments—for work that may be said without exaggeration to stand,

so far as absolute requirements are concerned, for glittering generalities.

But facts are more convincing that theories.

It was my duty something more than a year ago, as a member of a committee of the North Central Association of Colleges and Secondary Schools, to compile the requirements for admission, and for graduation with the A. B. degree, of a large number of colleges both within and without the association. On reading the facts of Mr. Swain's paper, I was immediately struck with certain coincidences. When you see what these coincidences are, you will doubtless be convinced that they are really cause and effect, and not mere coincidences.

The tables here presented are from the report of the Committee in the Proceedings of the North Central Association for the year 1905:

INSTITUTIONS IN NORTH CENTRAL ASSOCIATION—INSTITUTIONS REQUIRING LATIN AND GREEK FOR ADMISSION

	Latin Units.	Greek Units.
University of Chicago	4 (or 2)	2
Denison University	4	2
Drury College	4	2½
State University of Iowa	4	3 (May be done in college)
Iowa College	4	3
Missouri Valley College	3	2 (?)
Ohio Wesleyan University	4	3
Park College	4	2

REQUIRING LATIN.

	Latin Units.	
Colorado College	2	French or German, 2.
Cornell College	4	French or German or Greek, 2.
Knox College	4	
Lake Forest College	2	Other language, 2
Miami University	2	
Milwaukee-Downer College	4	Other language, 2
University of Nebraska	2	Other language, 1.
Northwestern University	4	(or Greek). Other language, 2.
Oberlin College	2	(or Greek). Other language, 2.
Olivet College	2	
Ripon College	4	Greek or German, 2.
Washington University	4	Other language, 2.
Western Reserve University	4	Other language, 3.

REQUIRING LANGUAGE, BUT NOT NECESSARILY LATIN OR GREEK

	Units.	
Albion College	2	
Beloit College	2	
University of Cincinnati	4	or 8.
University of Colorado	4	Latin preferred.
University of Illinois	2	for A. B. in Literature and Arts; not for A. B. in Science.
Indiana University	3	in one language.
University of Kansas	3	
University of Michigan	2	
University of Missouri	2	
Ohio State University	6	(?).
Wabash College	3	
University of Wisconsin	2	

REQUIRING NO LANGUAGE.

University of Minnesota.

INSTITUTIONS NOT MEMBERS OF N. C. A. REQUIRING LATIN AND GREEK

	Latin Units.	Greek Units
Colgate University	4	3
Princeton University	4	3
University of Pennsylvania	4	3
Syracuse University	4	3
Trinity College	4	3
Union University	4	3
Wesleyan University	4	3

REQUIRING LATIN.

	Latin Units.	
Amherst College	4	Greek or French or German, 2.
Boston University	4	Greek or French or German, 3.
Bowdoin College	4	Greek or French or German, 3.
Brown University	4	Greek or French or German, 2.
Dartmouth College	4	Greek 3, or French or German, 2.
Harvard University	4	French or German, 2.
Johns Hopkins University	4	Greek or French or German, 3.
Mount Holyoke College	4	Greek or French or German, 3
Smith College	4	Greek or French or German, 3.
Tufts College	4	
Vassar College	4	Greek or French or German, 3.
Wellesley College	4	Greek or French or German, 3.
Williams College	4	Greek or French or German, 3.
Yale University	4	Other language, 3.

REQUIRING LANGUAGE, BUT NOT NECESSARILY LATIN OR GREEK

	Units.
Columbia University	4
Cornell University	6

Mr. Swain's tables show that there has been a remarkable decrease in the number of students in high schools taking Latin, and especially that in Michigan, Minnesota, and Wisconsin there has been a startling decrease in the number of graduates having four years of Latin. Inspection of the North Central tables shows at once that in these states the state universities, and in their wake the smaller colleges of the state, have deserted the four-year entrance requirement in Latin for candidates for the A. B. degree.

In Iowa, there has been an increase in four-year Latin students. There we find the State University, Cornell College and Iowa College holding strictly to the four-year requirement.

Indiana shows a smaller decrease in the total number enrolled in Latin, and retains a much larger percentage of graduates taking four years of Latin than does Michigan. Here we find the State University and Wabash College demanding three years of one language. Experience shows that with this requirement Latin is the language usually taken.

In Illinois in the schools quoted, there is an increase in the number taking Latin, with a small decrease in the number of graduates with four years of Latin. These schools are largely in the northern part of the state, and here we find The University of Chicago, and Northwestern University, requiring four years of Latin.

In Ohio there has been an increase in the number taking Latin and a small decrease in those on the four-year basis. Here we find Western Reserve University, and Ohio Wesleyan University, requiring four years of Latin, the State University requiring six years of languages, which practically means Latin for four years, and the great influence of the eastern colleges on this, the most eastern of our states, all working together to upbuild the old standard of at least four years of preparatory Latin for the A. B. degree.

It seems impossible that anyone comparing the facts of Mr. Swain's paper with the facts of the North Central Association report can fail to convict the colleges of the Middle West of being the real foes of classical culture, responsible for the present lowering of standards in the high schools of the section. The unit system ungoverned, founded on the theory that anything under the sun in education is as valuable as anything else, is leading our boys and girls to seek easy "snap" courses which will admit them to many institutions whose well oiled doors swing open all too easily.

The question was asked whether Mr. Bliss would advocate the recognition of a single unit in Latin as a college preparatory subject.

Mr. Bliss placed the following table on the blackboard and continued as follows: Mathematics, 3; English, 3; Physics, 1; English Literature, 1; Physiography, 1; Chemistry, 1; Zoology, 1; Botany, 1; History, 1; a language (Latin, French, or German), 2.

This scheme of requirements is a possible one for admission to the university at the present time. It goes as far in recognizing single units as would seem safe or wise. It might be well for the university to follow the example of some eastern colleges and recognize a single unit of French or German, provided it is a third language; but otherwise the wisdom of the single unit seems doubtful. Too many single units mean dissipation of energy. What is needed is concentrated effort along definite lines of work, continuity, the power of sustained effort.

The school men are only too eager to demand this work of their students. If the colleges will set the standard, the schools will have no trouble in meeting it.

IV.

BY SUPERINTENDENT W. G. COBURN, BATTLE CREEK

I inferred from Professor Kelsey, when he asked me to discuss the excellent paper of Principal Swain entitled "Is Latin Holding Its Own in Public High Schools?" that he wished me to consider the question from the standpoint of our own schools; so I shall limit myself to the discussion of the subject in relation to our city, making only such comparisons and considering such conditions as my limited time will permit.

In some respects the Battle Creek High School has been particularly fortunate and because of certain favorable conditions, we should expect that Latin had suffered but little in recent years: First, the city is pre-eminently a city of the middle class, there being few of the extremely poor or the extremely wealthy. This middle class contains but little foreign element and is made up mostly of mechanics who are perhaps above the average intelligence of the wage earner.

Besides this, the traditions of the high school have been toward the classical course, and these traditions have been fostered and strengthened under the principalship of such men as Professor Hill, of Orchard Lake; Mr. Halsey, of Chicago; Professor Drake, of the University of Michigan; Superintendent E. C. Warriner, of Saginaw; and Mr. H. D. Nutt, all of whom were strong classical men. Again, it is possible that some of our students have felt indirectly the influence of such men as Professors Meachem, Hempl, Scott, and Meader, all of whom were graduated from our high school and were faithful adherents of the Latin course.

Our school boards of recent years have been much opposed to the idea of placing a full commercial course in our high school. We offer simply commercial arithmetic and book-keeping and the Board of Education holds that stenography and typewriting is a profession in itself and should be taught in a professional school or business college.

I mention these facts to show that the conditions are favorable to the study of Latin in our high school, but with all these favorable conditions we can show but one per cent better than the general average of the graduates having four years Latin in Ohio, or 61 per cent to 60 per cent in Ohio. In Indiana 71 per cent of the total enrollment has taken Latin, while we can show but 67 per cent. We find, however, that Indiana has but 34 per cent of the graduates who took four years of Latin. This sudden dropping off of those who take the Latin course caused us to tabulate the number of students of our high school by grades or years, and also by sections as Principal Swain has done. We find that during the past ten years the per cent of enrollment by grades has been as follows:

School Year	Total Enrollment of School.	No. Pupils 1st & 2d Year Latin.	No. Pupils 3d & 4th Year Latin.	Total No. Taking Latin.	Per Cent of Total Enrollment Taking Latin.	Total No. of Grad. for Year.	No. of Grad. who had 4 yrs. Latin.	Per Cent of Grad. who had 4 yrs. Latin.
1895-1896	328	168	42	210	.64	37	25	.67
1896-1897	357	268	67	335	.93	39	16	.40
1897-1898	355	195	67	262	.73	43	34	.79
1898-1899	358	155	58	213	.59	38	22	.58
1899-1900	414	180	21	231	.55	43	26	.60
1900-1901	376	161	48	209	.55	32	20	.62
1901-1902	394	210	71	281	.71	30	26	.72
1902-1903	385	209	67	276	.71	30	21	.70
1903-1904	372	188	62	250	.67	50	24	.48
1904-1905	417	212	41	253	.60	34	21	.62
Totals	3756	1946	574	2520	.67	382	235	.61

Per cent of total enrollment taking Latin for the past ten years:

	9th.	10th.	11th.	12th.	
Total Enrollment	1706	918	646	382	(counting only graduates.)
Total Taking Latin	1305	641	302	235	
Percent. Taking Latin.	76	70	47	61	

Total number of boys and girls who have taken Latin during the past ten years:

9th Grade.			10th Grade.			11th Grade.			12th Grade.		
Boys.	Girls.	Total.	Boys.	Girls.	Total.	Boys.	Girls.	Total.	Boys.	Girls.	Total.
498	807	1305	219	422	641	73	229	302	66	206	272

Why this great falling off at the end of the second year of the high school? The following reasons seem to affect the Latin with us, three of which Principal Swain has already given and Mr. McKenzie and the other speakers have practically covered all the others:

First, The fact that Latin is no longer required for the degree most desired by many prospective college students.

Second, The larger number of electives now offered.

Third, The disinclination on the part of some students to hard work. It is harder to look forward to four years of Latin than to four years of science.

Fourth, All engineering courses of the University of Michigan require but two years of Latin and this has influenced many of our boys to take but the two years of Latin.

Fifth, Better laboratory facilities and more courses in science detract from the study of Latin.

Sixth, A few drop Latin to take up German or French after the second year.

Seventh, The second year Latin is considered by the teachers to be the dullest year in the study of Latin. Many pupils become discouraged.

We urge the bright pupils when in the eighth grade to take the Latin in the high school. We should try to save more at the end of the second year of high school by having the pupils understand better the value of the study of Latin.

The study of Latin should be more attractive. The Latin teacher must compete with the advanced ideas and more attractive ways of presenting the subjects in science, history and mathematics.

V.

BY PRINCIPAL J. R. BISHOP, EASTERN HIGH SCHOOL, DETROIT

Principal Bishop continued the discussion by commenting upon Professor Williams' suggestions and upon the attitude of the Department of Medicine toward Greek. He commended the suggestion of Professor Williams that elementary physics and biology be placed in the second year of the preparatory course, leaving room for a second language beside Latin in the third and fourth years. He assailed the present requirement of physics from all applicants for entrance into all courses of the university. This requirement leads, Dr. Bishop thinks, to confusion of aims, and insincerity and superficiality. The course as at present conducted in Michigan high schools seems to be, on paper, practically a freshman course in physics, laying the foundation for higher work in applied mathematics. It requires much laboratory work and extremely rapid covering of ground in the text book. A few pupils might be expected to compass this work; many of those who now take it because they must, in order to enter the university, show sorry results when closely tested. If an elementary course of physics informational in character, were placed in the second year, it would help make pupils intelligent regarding the modern world of mechanical achievement and not unduly tax their undeveloped powers of observation and research.

IS THE AENEID A COMPLETE POEM?

PRINCIPAL MAUDE A. ISHERWOOD, GRAND HAVEN HIGH SCHOOL

That such a question has been asked is significant. It seems to imply that some one has been dissatisfied with the great Roman epic, that some one has considered that the story of the poem was not finished. We find that it was with none other than the author of the Aeneid himself that this idea originated, for at his death he requested that the poem be burned because he did not consider it finished. It would seem, then, as if there were no question of its incompleteness, but let us ask ourselves what Virgil meant by "not finished."

First, did he consider it incomplete because he intended to add twelve more books? The Iliad has twenty-four books and the Odyssey has twenty-four books. Should the Aeneid also have had twenty-four? We all know that the first six books correspond to the Iliad, while the Odyssey has its counterpart in the last six. It would therefore not seem that Virgil wished to determine the number by the Homeric epic or he would have followed more nearly the outline of its content. Moreover, the number twelve was a significant one for the Romans. There were twelve Tables of the Law and twelve was the basis of their system of decimals.

Suppose, however, that Virgil had intended to write twelve more books. What would have been the nature of the content of these twelve books? In true epic style, Virgil outlines his subject in the first eleven lines: "I sing of arms and the man." The man of course is Aeneas, and the whole poem as it now stands has for its subject "arms and Aeneas." If, however, the story had been continued for twelve more books after Turnus' defeat, the subject could still have been "arms," but the remaining career of Aeneas would have furnished meager material for several more books, and another hero would have been necessary. Following through the other lines of the subject: "Of arms I sing and of the hero who from the coasts of Troy by fate's decree, an exile, first came to Italy and Lavinium's shore, much buffeted both on land and on the deep by violence of the gods to sate vengeful Juno's unrelenting wrath; many hardships also even in war enduring, while he strove to found a city and secure his gods a home in Latium; from him the Latin race, our Alban sires and the walls of lofty Rome." Or, briefly, "I sing of arms and of the hero who came to Italy, endured many hardships in war while he strove to found a city and secure his gods a home." And this is just what Virgil tells in the twelve books of the Aeneid. He tells of Aeneas, his coming to Italy and the trials he endured in war until he found a home for his gods. According to his own outline he did not intend to make the founding of Rome and the growth of Roman empire a part of his poem. He is telling merely the story of the man from whom should spring "the Alban sires, and the walls of lofty Rome." And the twelfth book stops just when a home for the gods had been made in Latium, or, in other words, it stops just where the introductory statement of the subject told us it was to stop.

Again, had another twelve books been added and the history of the Trojans, of their assimilation with the Latins and of the resulting Roman race been fully treated, would not Virgil have been guilty of repetition? For, if we fit together the prophetical passages of the Aeneid we obtain an excellent outline of Roman history. In Book I we find that Aeneas, after carrying on a great war, will establish his people, give laws and rule three years in Latium. After his death Ascanius will rule for thirty years and build Alba Longa where his

descendants will remain for a hundred years until Romulus builds Rome. Book VI gives the outline of the time of the kings, Numa, Tullus, Ancus and the Tarquins, and then adds a list, not chronological of the great men to the time of Virgil—Brutus, who drove out the Tarquins, Cossus, Camillus the Decii, Torquatus, Regulus, the Fabii, the Drusi, Paulus Aemilius, the Scipios, Cæsar and Pompey, while the eighth book adds Catiline and the Battle of Actium and Augustus' glorious career while the death of Marcellus is beautifully told in Book VI. Thus these prophecies, beginning directly after Turnus' death bring the Aeneid to Virgil's day. To be sure, there are prophetical passages which are later fully explained, but how differently they are expressed! They are vague, almost enigmatical, attracting our interest to the final manner of their fulfillment. Among such passages are the curse of the Harpies, the meeting with Scylla. These whet our interest. But those prophetical passages which treat of times not falling within the scope of the subject as outlined by the writer himself are so treated that we are satisfied, that we receive a definite idea of those times—an idea so definite that we know it will not be necessary to add twelve more books to retell them. Therefore Virgil evidently did not mean that he intended to add twelve more books to his Aeneid for the content of those books should and would have had equal mention in the statement of his subject and, secondly he had already covered the remaining period of Roman history by his prophetical passages.

Then, what did Virgil mean when he called the poem unfinished? Perhaps he intended to add some more lines to the last book. Although the twelfth book is now longer than any other, let us try to follow the suggestion. What shall be added? Heyne suggests as closing lines. "Aeneas immediately after this victory received Lavinia in marriage, united his Trojans in one nation with the subjects of Latinus under the common name Latini, built the city of Lavinium and obtained the right of succeeding to the kingdom of Latinus. Thus he secured a dwelling-place in Italy, and introduced his gods into Latium according to the purpose indicated in the beginning of the poem." You remember the close as it now stands, how the two heroes were fighting the finish, how Latinus begs for his life, how Aeneas, seeing the belt of his friend, says that he cannot grant the request and

> "Thus as he spoke his sword he drave
> With fierce and fiery blow
> Thro' the broad chest before him spread;
> The stalwart limbs grew cold and dead;
> One groan the indignant spirit gave,
> Then sought the shades below."

Can you imagine anything so tame as to add that the victor received Lavinia in marriage? Of course he did. Had he not been fighting for her throughout the last six books? Had not the compact been that he who survived the single combat should have her for his wife? Do we

need to have it said that Aeneas unites the Trojans and Latins in one nation? Was not that also a part of the compact? No, that could not have been the intention of a true poet. Virgil neither intended to add twelve more books nor twelve more lines.

There is left then only one possible conclusion as to Virgil's reason for requesting that the manuscript be burned because unfinished. Virgil felt that the Aeneid was not such a perfect work as he would like to hand down to posterity. His ideal was so high, his poetic sense so acute that he felt dissatisfied. We ourselves can sympathize with this feeling when we compare the first books which he had had time to revise with the last and note the higher degree of perfection attained by the revision. Sellar says: "Had Virgil lived to devote three more years to the revisal of his work, there is no reason to suppose that he would have added anything to its substance. Some inconsistencies of statement would have disappeared and some difficulties would have been cleared up. But the chief part of his labor would have been employed in bringing the rhythm and diction of the poem to a more finished perfection than that which they present at present. The unfinished lines in the poem would certainly have been completed and more closely connected with the passages succeeding them." And this is what Virgil meant when he was dissatisfied, and we are convinced that the Aeneid ends just as Virgil wished it to end.

JUVENAL'S TENTH SATIRE AND DR. JOHNSON'S VANITY OF HUMAN WISHES

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In no other age was English literature so affected by Latin as in the eighteenth century. As the hexameter found its perfection in Virgil, so the heroic couplet under the labored efforts of Pope became the model of poetic expression. And likewise in prose we see in Johnson the same finished periods that characterize the writings of Cicero. Though the fundamental causes for this similarity may lie in the social and political conditions of the English people, still a great deal of the likeness is due to the studied imitation of classic models. So close and enthusiatsic was this study that there sprang up a sort of pedantic pride, exhibiting itself in heading poems and chapters, and in scattering profusely throughout a work of prose quotations from the ancients. Naturally there also arose numerous imitations and translations, such as Dryden's Persius and Virgil, Pope's Iliad and Odyssey and his Imitations of Horace, to say nothing of previous attempts such as Oldham's excellent imitations of Juvenal. Thus we see that classical literature had become a vital element of the age.

The last great representative of this period was Samuel Johnson. Like many other learned men of his time, he had a sincere reverence for ancient literature, derived from an extensive and thoughtful reading of classic writers, especially of the Latin. As an example of his conversance with Latin literature, I quote from that inexhaustible biography of Boswell, who, in speaking of Johnson's imitations of Juvenal, says: "I remember when I once regretted to him that he had not given us more of Juvenal's Satires, he said he probably should give more, for he had them all in his head; by which I understood that he had the originals and correspondent allusions floating in his mind, which he could, when he pleased, embody and render permanent without much labor." [Boswell's Life of Johnson, page 63. Globe Edition. Ed. Mowbray Morris. Macmillan & Co. 1903.]

It is to this familiarity with Juvenal that we owe Johnson's London, an imitation of Juvenal's Third Satire, and his more famous imitation of the Tenth Satire, entitled The Vanity of Human Wishes. I have used the word famous, and yet I fear it is more famous than generally familiar. We of later generations have allowed it, and unjustly so, to lie upon our shelves, hidden away in a formidable volume of its author's Rambler, until the title of that volume has grown dim with the dust of years. And yet in spite of the diffidence and ignorance that may exist in regard to it, I make no apology for its resurrection; for the merit it possesses, I believe, will repay us for all the time we devote to it.

My first acquaintance with this poem came after I had read the Latin original; and I was at once struck by the dissimilarity between the two where I had expected to find similarity. I was still further surprised, in reading criticisms, to find that in them all the idea was conveyed that the English poem was a successful imitation of the Latin. This led me to work out a detailed comparison of the two satires, of which this paper is an outline.

Before entering upon the comparison of the two masterpieces, let us see if we can find a dissimilarity in their authors' attitudes toward life which will account for the dissimilarity in the poems. The meagreness of historical evidence relating to the life of Juvenal compels us to judge of him from what he has left written. This judgment is largely personal, depending upon our interpretation of the satires. The prevailing opinion has been, and is shared yet to a large extent, that Juvenal was a stern moralist and a pessimist, railing against all human kind. It is claimed that when he wrote *Facit indignatio versum* [Satire I-79], he meant what he said. But those who maintain this view forget that Juvenal is above all a satirist. Among the very requisites of satire are exaggeration, ridicule, and humor. Take these away and the satire is gone, and what is left is a moral platitude. We can no more expect that Juvenal is sincere in all that he says than we

can suppose that the pictorial satires of today, as depicted in our cartooons, are a true reflection of the artist's beliefs and thoughts.

How can we believe, for example, that Juvenal is sincere in his humorous description of Rome in the Third Satire? "I do not like," says he, "a Greek city. * * * * I cannot lie, nor can I praise a book if it is bad; I cannot tell fortunes by the stars, nor have I ever observed the vitals of frogs." The humor of this lies in its exaggeration; as if all Rome were so filled with foreign upstarts, that the only occupations were those of flatterer, astrologer and soothsayer, in which there was no chance for the sons of Romulus. To interpret these words literally is to destroy the humor. Juvenal realizes the untruth in his statement, just as at heart we all do when we satirically speak of old maids as sour and finicky, or of the proverbial mother-in-law as the incubus of the household. It is this humor, whether it be the humor of wit, exaggeration, or situation, that gives life and zest to Juvenal's satires. It is the one thing that makes him enjoyable, that marks him the true satirist. Indeed satire without humor sinks to mere abuse and invective, or at the best becomes a trite moralism.

This humor in Juvenal crops out everywhere, even in the midst of his serious discourse. Many are the instances where the sudden anti-climax renders the preceding majestic lines nothing but a mock solemnity. And so from the standpoint of the true satirist it is natural to conclude that Juvenal believes but a part of what he says. His sincerity extends only so far as the moral purpose of his satire is concerned. This purpose is only the kernel, around which he heaps a wealth of ridicule, of humorous illustrations and situations. Therefore, in view of Juvenal's wonderful power as a satirist, I cannot believe that he went through life with a grim and foreboding countenance, or that he was, like a cur, always ready with a snarl and a bite. It is more natural to think of him, indeed, as one whose eye was always open to the humorous side of life; whose friends, I imagine, often found him laughing, even though at times the laughter may have been cynical and bitter. It is this shrewd sense of the ridiculous and humorous that characterizes the Tenth Satire, and differentiate it from its imitation by Johnson, to whom we shall now turn our attention.

There is no doubt that Johnson was an out and out pessimist. To read his Rambler is like going to a funeral. His sentences march along in solemn and heavy array, and his thought is fully equal to his style. The following is a quotation from the Rambler, cited by Leslie Stephen in his Life of Johnson [English Men of Letters Series, page 175. Harper Bros. 1878.] It illustrates both his style and his view of life.

"The cure for the greatest part of human miseries is not radical, but palliative. Infelicity is involved in corporeal nature, and interwoven with our being; the armies of pain send their arrows against us on

every side; the choice is only between those which are more or less sharp, or tinged with poison of greater or less malignity; and the strongest armor which reason can supply will only blunt their points, but cannot repel them."

No wonder that the subject, "The Vanity of Human Wishes," which is also the theme of his story of Rasselas, was especially attractive to him. The sentiment of Juvenal's Tenth Satire, therefore, fitted in perfectly with the doctor's state of mind. To Johnson the moral and didactic element in Juvenal overshadowed all else. It was his unswerving rule never to allow much of the lighter vein to creep into anything which he was to offer for publication. As a result his writings are permeated with moral platitudes.

This moralizing of course entered into his conception of poetry. He was of the old school of Dryden and Pope, and so to him the didactic and logical element was the chief characteristic of poetical composition. As Leslie Stephen says, [page 187, in volume cited above], "He always inquires what is the moral of a work of art. * * * * He condemns not only insincerity and affectation of feeling, but all such poetic imagery as does not correspond to the actual prosaic belief of the writer." As a proof of this remark we need only to read Johnson's criticism of Milton's Lycidas in his Lives of the Poets. [Johnson's Lives of the Poets, page 96. Ed. Matthew Arnold. Macmillan & Co. London. 1892.]

"In this poem (Lycidas)," writes Johnson, "there is no nature, for there is no truth; there is no art for there is nothing new. * * * * Its inherent improbability always forces dissatisfaction on the mind." And after a little he quotes Milton's lines, "We drove afield * * * * Battening our flocks with the fresh dews of night," and adds, "We know that they never drove afield; and that they had no flocks to batten;" and still farther down we read, "Nothing can less display knowledge, or less exercise invention, than to tell how a shepherd has lost his companion, and must now feed his flocks alone, without any judge of his skill in piping; and how one god asks another god what is become of Lycidas, and how neither god can tell."

Such is Johnson's conception of poetry. Add to it his pessimistic moralism, and such a poem as The Vanity of Human Wishes becomes the inevitable outgrowth of his state of mind; for, naturally enough, we shall find it a sober, earnest, plodding poem, and yet filled with a dignity of language and thought that places it among the great poems of that school which wrote only in heroic couplets. To expect to find in Johnson the characteristic satire and humor of Juvenal is to presuppose an affinity between them which does not exist. Johnson is always reverent, conservative, sincere, and moralistic, qualities that certainly do not enter into the make-up of a great satirist, such as Juvenal. We are therefore not a little surprised to read in Macaulay's famous essay on Johnson that, "What Pope had done for Horace, John-

son aspired to do for Juvenal. The enterprise was bold, and yet judicious. For between Johnson and Juvenal there was much in common, much more certainly than between Pope and Horace." [Macaulay's Life of Johnson in Matthew Arnold's edition of Johnson's Lives of the Poets, page 12. Macmillan & Co. 1892.] We can indeed agree with Macaulay that "the enterprise was bold;" but that it was "judicious" because of the likeness between Juvenal and Johnson is about as false as to say that Pope's translation of the Iliad and Odyssey was judicious because Pope had much in common with Homer. Let us now see how this judgment concerning Johnson and Juvenal is substantiated by the poems under discussion.

The limitations of space permit me to select only two or three characteristic passages for comparison. As to the poems as a whole, it will be sufficient to say that Johnson has closely followed the structure of Juvenal, using the same logical development, but drawing his illustrations from English life and history. Each satirizes in turn the wish for fortune, power, eloquence or literary fame, military glory, long life, and beauty.

One of the most humorous parts of Juvenal's poem is the satire on the wish for eloquence. Says Juvenal, "Why, even the little school urchins long for the fame of Demosthenes and Cicero, aye, and they keep on longing the whole year round, vacations and all." Then he cites that most wretched and jingling verse from Cicero's poem on his consulship, a verse filled with unbearable conceit, *O fortunatam natam me consule Roman* [Satire X-122]. And Juvenal adds, "If Cicero had written everything as bad as that, he could have scorned the swords of Antony. I should rather have been a ridiculous poetaster than have written thee, O thou divine Philippic of conspicuous fame." And he ends up with the humorous picture of the blear-eyed father of Demosthenes sending his boy from the felicity of a blacksmith shop to the unhappiness of an oratorical career.

But when we have read this passage and enjoyed its fun, we begin to wonder what it is that Juvenal is driving at; for surely eloquence and rhetorical training are worth striving after. Does Juvenal want to take away all intellectual attainment? Does he think his argument is good when he cites two so great careers as those of Cicero and Demosthenes? Almost any school-boy would reply, and justly, too, "Give me their eloquence, their honors, and I'll risk their fate." The whole argument is in fact nothing but pure sophistry. And of course Juvenal knew it was when he wrote it. There are some who will call this pessimism, or perhaps a case of "sour grapes." But Juvenal was a man of too much sense to make seriously such an argument as we find here. We must remember that sophistry is a natural means of satire; and, indeed, to a decided optimist all satire would be more or less sophistical. In fact the whole argument of this poem is based on insufficient evidence. We must dig below this false reasoning of

Juvenal to find the lesson he has for us. Juvenal knows he is exaggerating, but his purpose must be accomplished. What this purpose is we shall see when we come to discuss his conclusions.

The corresponding passage in Johnson consists of thirty-nine lines, over twice as many as Juvenal's. Johnson directs his satire, not against eloquence but against literary and scholarly fame. Unlike Juvenal, he is entirely serious, and, above all, sincere; for his own life was filled with enough hardships and disappointments to afford him sufficient grounds for dissuading against a literary career. Here surely Johnson has selected a much better object for satire than Juvenal; wherefore his reasoning is much the stronger. "Though you should escape all temptations," says Johnson, "and take science captive in her own retreat, * * * *

> Yet hope not life from grief or danger free,
> Nor think the doom of man reversed for thee.
> Deign on the passing world to turn thine eyes,
> And pause a while from letters to be wise;
> Then mark what ills the scholar's life assail,
> Toil, envy, want, the patron, and the jail.
> See nations, slowly wise and meanly just,
> To buried merit raise the tardy bust."

These lines, unlike Juvenal's, enforce our respect. Indeed, we can almost agree with Macaulay in his criticism, when he says, "Johnson's vigorous and pathetic enumeration of the miseries of a literary life must be allowed to be superior to Juvenal's lamentation over the fate of Demosthenes and Cicero." [Page 15, Johnson's Lives of the Poets. Ed. Matthew Arnold. Macmillan & Co. 1892.] Of course in accepting this criticism of Macaulay we are placing Johnson above Juvenal as an earnest and sincere writer, not as a humorous and sophistical satirist; for Johnson's lines are too mild and sober to be called satire. And, too, we hope that Macaulay did not imagine, though I fear he did, that "Juvenal's lamentation over the fate of Demosthenes and Cicero" was a real one, washed with true tears.

Omitting the satire on military life, in which Johnson offsets Juvenal's Hannibal with his famous lines on Charles the Twelfth of Sweden, we come to Juvenal's satire on the wish for long life. To judge from the number of lines (there are a hundred of them, almost a third of the whole poem) and from the wealth of illustration, we might think it was the most important part of the satire in Juvenal's opinion. And perhaps it was, for we have one of the finest examples of his descriptive power, enlivened, as it always is, by his characteristic humor. To be sure the humor is a sort of gruesome thing that jars on our finer sensibilities, and compels us, if we would enjoy it, to keep in abeyance our natural feelings of pity and reverence. "Look at the old fellow," says Juvenal, "He hasn't any skin. It's all hide. See his flabby cheeks, and such wrinkles as only a baboon, sitting in an African jungle, could dig into her pate. He has to munch his food,

for his teeth are gone. Look at his bald head, and his nose drivelling like a baby's. He's a nuisance to his wife, his children, and himself. He's pleased with neither drink nor victuals. He wouldn't start at a blast of trumpets. Around him are leaping a whole tribe of diseases, sciatica, rheumatism, lumbago and I know not what. I could tell more easily how many patients a quack will kill off in an autumn. He's fed as if he were an infant, and stretches his mouth for his food like a young bird goping for the worm in its mother's bill. He has forgotten everything, even how his own children look. And he ends up by becoming the dupe to a pleasing wench. But even if you escape all this," adds Juvenal, "yet your old age will be filled with sorrow over the loss of friends." And he goes on to give us examples, ranging all over the field of mythology and history. Again he breaks forth into his humorous strain, "There's Nestor, who, if what Homer tells us isn't a lie, lived nearly as long as a crow, only at last to complain of the laws of fate and too much thread when he beheld on fire the beard of Antilochus." As further illustrations of a too long life, we have Peleus mourning Achilles; Ulysses mourned by his father; Priam beholding Troy and her woes, and "perishing before the altar of Jove, like an old ox offering up its scrawny neck to its master for slaughter. Yet he died a man's death. But Hecuba, his wife, came to a worse fate, for she lived to turn into a barking cur. Then there was Mithridates and Croesus and our own Marius with their miserable fate. Campania with providential foresight, would have given to Pompey the fevers which he ought to have wished for. But," adds Juvenals with a bitter fling at religion, "the public prayers prevailed, and so he was spared only to be conquered and to lose his head, whereas the Catilinarian conspirators got off with whole carcasses."

Such is Juvenal's attack on the wish for old age. That a large part of it is pure sophistry, is plain enough. If it were all serious argument, for what purpose is all that absurd attempt to convince us with mythological evidence of that which Juvenal himself impugns by his ridicule? The conclusion is obvious enough—Juvenal is satirizing not only the wish for old age, but also incidentally the old belief in legends and myths. And so we cannot think of this tirade against old age in any very serious mood.

Let us now turn to Johnson's version. We find, as we should expect, a very careful and serious argument. It is no joking matter with the doctor. He first describes the ills attendant upon old age, in which you may be sure there is no comparison to a baboon. For Juvenal's humorous description of the old man's loss of hearing, we find in Johnson these affected and verbose lines:

> "Approach, ye minstrels, try the soothing strain,
> Diffuse the tuneful lenitives of pain;
> No sounds, alas! would touch th' impervious ear,
> Though dancing mountains witnessed Orpheus near;
> Nor lute, nor lyre, his feeble powers attend,
> Nor sweeter music of a virtuous friend."

But the next few lines are a decided improvement—

"But everlasting dictates crowd his tongue,
Perversely gross, or positively wrong.
The still returning tale, or lingering jest,
Perplex the fawning niece and pampered guest,
While growing hopes scarce awe the gath'ring sneer,
And scarce a legacy can bribe to hear."

After describing the avarice of old age, a phase which Juvenal neglects, Johnson discusses that old age which by a virtuous life has escaped the usual maladies attending a wicked one. We remember that Juvenal introduces the subject in four words, *ut vigeant sensus animi* [Satire X-240], and then starts in with the catalogue of woes that afflict even such an old age. But Johnson is too conscientious to make any such flippant argument as this. He perceives the injustice in Juvenal's treatment, for he feels that such an old age is not absolutely to be deplored. And so those four words of Juvenal he expands into eight lines—

"But grant the virtues of a temp'rate prime,
Bless with an age exempt from scorn and crime;
An age that melts with unperceiv'd decay,
And glides in modest innocence away;
Whose peaceful day benevolence endears;
Whose night congratulating conscience cheers,
The gen'ral favorite as the gen'ral friend;
Such age there is, and who shall wish its end?"

It is here that we see a fundamental difference between Juvenal and Johnson. Juvenal is not at all considerate of either beauty, authority, or reason. Priam is like an old ox, and a virtuous old age has no attractions whatever. The goal is the all in all with Juvenal, and he rides rough shod over everything until he reaches it. There is no logic, it is all force. But Johnson is very careful about what he says. Everything is propped up as he goes along in his slow and positive manner. He cannot dismiss an argument in a line; he must exhaust it and make it convincing. Both men of course knew that there was nothing so very deplorable in the life of a good old man. But Juvenal feels no scruple in utterly ignoring the beauty of such a life; whereas the good old doctor's conscience pricks him. He might meet some of his friends on the street who would take him to task for so unjustly abusing old age. And so he inserts the above lines as a sort of an apology to the succeeding lines, quoted below, in which, by the force of his pessimistic nature, he makes as a serious argument what in Juvenal is a half-hearted and sophistical contention. Says Johnson—

"Yet even on this her load Misfortune flings,
To press the weary minutes' flagging wings;
New sorrow rises as the day returns,
A sister sickens, or a daughter mourns."

With Johnson the vanity of human wishes is a certainty, and he goes about to prove it with an earnestness and sincerity that cannot be questioned.

And, now, after all this arraignment of human wishes, what inference is induced for us by our pagan and our Christian poet? It would seem from the enobling influences of Christian faith that in the modern poem we should find a rule of life so ideal and beautiful that it needs must far surpass anything that could come from the intellectual and soulless beliefs of ancient philosophy. But to our surprise we find the opposite to be true. The pagan and stoical Juvenal gives us a more helpful and hopeful view of life than does the Christian doctor. And yet this need not surprise us so much; for we see between their conclusions that same difference which we have already noticed in the men themselves. Johnson's pessimism, which dominated in all he ever wrote, draws for us a withering and negative conclusion. Life is a vale of sorrow for man, to whom, as Johnson puts it, "Death is kind nature's signal for retreat." There is nothing positive for man to do in life. He is at the mercy of God, and his only crumb of comfort is that at the end there is some mysterious "best." As we have already noted in the quotation from the Rambler, the cures for human ills are not "radical but palliative." Let man bear it all with passive resignation. The *carpe diem* of Horace was an idea entirely foreign to the doctor's mind. Such is Johnson's philosophy of life. It is Puritanic, but surely it is not Christian. We finish the poem and come away with the funeral knell of life ringing in our ears.

But with Juvenal it is far different. Instead of a passive resignation to a mysterious Providence whose only aid is a shadowy hope of a life to come, we find in the pagan poet that positive and stoic endurance which lifts the individual above his environment, giving him enjoyment of life in spite of the blows of fate. Man's own will, and not death, is the panacea of his woes. To Juvenal the individual is supreme. To be sure he speaks of trusting all to the gods, but almost in the same breath he utters a facetious remark about offering up "the sausages of your little white porker," a joke rather disparaging to the divinities, which may well cast doubts upon the sincerity of Juvenal's religious faith. God to him is rather the personification of will, for he says, "I tell you that which you can do for yourself." Thus does Juvenal consistently with the stoic point of view, make man the arbiter of his own passions, and thus he is able to prefer "the sorrowful labors of Hercules to love and feast and downy couch." Therein lies the secret of happiness. Wish not for glory, or love, or power, but rather for self-control, "a sound mind in a sound body, and a brave spirit free from the terror of death." Is this pessimism? Is Juvenal looking at us with a sour and gloomy countenance? Is it not rather a positive and helpful view of life? Throw around it the softening and supporting influence of Christian love and immortality, and we have a true ideal for which to strive.

Now, having seen the conclusion, we can easily understand the true motive of Juvenal's satire upon human wishes. It is not the particular wish that Juvenal warns us against, but rather

the act of wishing in itself, which is so often a misdirected ambition centering about the individual. And thus we see that the sophistries of such arguments as those against the wish for eloquence and old age are merely that common satirical device by which the satirist impresses more deeply the lesson he wishes to convey. And this lesson, as we have seen, is that the individual should be master of himself rather than yield to the common passions and desires of mankind.

Such is Juvenal's Tenth Satire, and such is Johnson's imitation, The Vanity of Human Wishes. The opinion is prevalent that Johnson's poem is a successful imitation. For example, in the article on Juvenal in Harper's Dictionary of Classical Literature and Antiquities, we read in connection with the Third and Tenth Satires, the following criticism: "It is these two satires that Dr. Samuel Johnson paraphrased in English in his two poems, London and The Vanity of Human Wishes, with a fire and force and epigrammatic terseness of language that are in no respect inferior to the original." Again in the article on Juvenal in the Encyclopædia Britannica (9th edition) we read, "Johnson's imitations of the third and tenth satires in the London and Vanity of Human Wishes will convey to readers ignorant of Latin a good impression of the power of the original." So far as concerns The Vanity of Human Wishes, both these criticisms are misleading and false. As applied to the London they are only partially true, since in that poem Johnson, suppressing his own feelings, has transcribed a portion of the humor and ridicule of the original. As another example of this conventional criticism of Johnson as an imitator of Juvenal, I quote from a note on Juvenal in the explanatory index to an edition of Macaulay's Life of Johnson by A. P. Walker [D. C. Heath & Co. Boston. 1904.], a book used in our secondary schools: "Johnson was preceded in his imitation of the third satire by the English satirist Oldham, and by the French poet Boileau; but Johnson has the best claim to the title of 'the modern Juvenal.'" And Gosse, in his History of Eighteenth Century Literature, says of The Vanity of Human Wishes: "But it is perhaps the most Roman poem in the language, the one which best reflects the moral grandeur of Latin feeling and reflection." [A History of Eighteenth Century Literature, by Edmund Gosse. Macmillan & Co. London. 1901.] All these writers have failed to appreciate the fundamental difference between Juvenal and Johnson. They forget that Juvenal is a satirist, and that Johnson is a moralist. The power of Johnson's poem is due to its sincerity of purpose, and dignity of language. It fails utterly in satirical power, and hence is not a satire, but merely a didactic *tour de force,* a sermon written in rhyme. Take from Juvenal's Tenth Satire all its grotesque terms of expression, its anti-climaxes, its ridicule and its exaggeration, that is, deprive it of the essential features of satire, and then expand what we have left, and we should have something approximating to Johnson's

imitation. We must therefore look upon Johnson's poem as an imitation in form, but not in spirit. We might almost say that Juvenal's poem is a parody of Johnson's. As far as form is concerned Johnson is equal to Juvenal, and at times superior. Juvenal is not so careful about the connection of part to part. For often the wealth of his illustration leads him into disproportion, as is the case with his diatribe against old age. Johnson has, however, elaborated his theme very carefully ,and as a result we have a poem almost as finished in style as are those of Pope. But outside of this form and a certain dignity of expression, a dignity which in Juvenal is often a mere mockery, the likeness ceases between the Latin and the English poem. And, so, as a truthful imitation, The Vanity of Human Wishes is a failure. It is rather, therefore, to be looked upon as an original production, stamped with an individuality, which, if it does not gain our admiration, at least commands our sincere respect.

CONFERENCE OF PHYSICS AND CHEMISTRY

EQUIVALENT WEIGHT OF MAGNESIUM

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This experiment is not given with an idea that it contains anything new or novel, but because it is simple and successful.

A piece of magnesium ribbon 1 meter long is weighed and cut into lengths of 4 cms. each. This is done by the teacher. The pupil fills a 6-inch test tube with water at room temperature and inverts it in an evaporating dish partially filled. One of the small pieces of magnesium, whose weight is now known, is coiled about a rubber band and put under the test tube, the edge of the tube resting upon the rubber band and thus preventing the effervescence of hydrogen from carrying the magnesium into the upper part of the tube (Fig. 1). A few drops of sulphuric acid are poured into the evaporating dish and the hydrogen produced is collected in the tube. After the metal is completely dissolved, the apparatus is allowed to stand for a few minutes to come to the room temperature. Then a label is placed on the tube to indicate the volume of hydrogen, the tube being held steady with a test tube holder to avoid warming the gas by contact with the hands. The volume of hydrogen is obtained by removing the test tube and filling

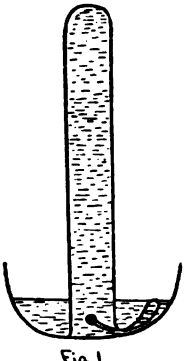

Fig 1

Fig 2

it with water from a burrette up to the label (Fig. 2). This volume is reduced to standard conditions and its weight computed. The ratio is then obtained between the weight of magnesium used and the weight of hydrogen obtained. It is seldom that the error amounts to 1 per cent. We find the experiment particularly valuable immediately after studying Boyle's Law and Charles' Law.

ARE THE ELEMENTS TRANSMUTABLE, THE ATOMS DIVISIBLE AND FORMS OF MATTER BUT MODES OF MOTION?

BY PROFESSOR S. LAWRENCE BIGELOW, UNIVERSITY OF MICHIGAN

The advance workers in chemistry and physics are constantly accumulating new facts and propounding new theories which must be digested and incorporated in the body of the sciences. The process of assimilation is often slow, and it is right that new and important facts should be vouched for by more than one investigator, and that a new theory should prove its usefulness, before being placed beside old and tried facts and theories. But too often the effects of the advances are unduly delayed through a reluctance to revise old text-books or old lectures, perhaps not so much because of mere laziness as because of a failure to appreciate the full force of the evidence in favor of new views, or of the advantages to be obtained by their adoption. The fact that the arguments for an innovation, for a time at least, are scattered through many journals, leads to an under-estimate of their cumulative force.

It is the purpose of this article to gather the main facts, some old, many recent, most of them fairly generally known, which are compelling us to alter our old definitions, and to show what a strong argument they make in favor of believing in the transmutation of the elements, the divisibility of the atoms and that what we call matter is simply a mode of motion.

It is interesting to note the caution with which text-books express themselves when it is necessary to give definitions for these terms. By a careful choice of words most authors avoid making false statements, but they certainly do frequently lead their readers to unjustifiable conclusions. For instance, in Roscoe and Schorlemmer's "Treatise on Chemistry, issued in 1891, we find the definition, "An atom is the smallest portion of matter which can enter into a chemical compound." As is the usual custom, the ideas of the alchemists regarding the possibility of transmuting metals is held up to ridicule, and thus, by implication at least, the ultimate nature of the elements and the

idea that the atom is indivisible is infallibly conveyed to the reader. A more recent instance is to be found, even in the late editions, of one of the most widely used texts on general inorganic chemistry. In this book, on page 4, we read, "Molecules may be defined as the smallest particles of matter which can exist in the free state;" on page 5, "Atoms are the smallest particles of matter which can take part in a chemical change;" on page 6, "Molecules consisting of atoms of the same kind are termed elementary molecules, and substances whose molecules are so constituted are known as elements." The numbers of the pages on which these statements occur are also significant. This reminds one of the methods of the old Greek philosophers, who pretended to solve all questions of science by pure deduction, positing some hypothesis, and then developing everything else by meditation in their closets, disdaining to disturb the order of their thoughts by experiments. But it is unworthy of the present age of inductive science, wherein every thought has, or should have, experimental evidence as its starting point. It can not be said that this particular author has made a false statement, but he has left the subject incomplete; cautiously reserving a loophole for his own escape, he fairly traps his readers. For it is inevitable that, with such didactic phraseology, and without having his attention called to the hypothetical, the tentative, nature of these definitions, the student should become convinced that the most fundamental facts of chemistry are that there are about eighty substances so simple that they can never be broken up into simpler things, and that all substances are composed of ultimate particles, called atoms, eternally indivisible.

A student started out with this hodge-podge of fact and theory thoroughly implanted in his mind as the basis for all his future knowledge, is sadly handicapped, indeed he is intellectually maimed, and it may take him years to overcome the habit of confusing fact and theory, and to learn how to think straight; perhaps he never succeeds in overcoming it. This confusing of facts with theories is a vicious habit which grows till it colors all one's thoughts, hinders the free play of the intellect, diminishes the power of right judgment, and starts the ossification of the wits even before the age set by Dr. Osler.

It is not necessary to consider a student of chemistry as an infant in arms to be fed on predigested food. He may be assumed to have a digestive apparatus of his own. Give him the benefit of any doubt and ascribe to him at least a dawning intelligence, which, properly stimulated, may some day shed some light of its own. It is the characteristic course of a lazy teacher, and one pleasing to lazy students as well, to supply a lot of personal opinions in the shape of cut and dried definitions, so easy to memorize and, unfortunately, so hard to forget; phrases which do not require the intellect to bestir itself and exercise its faculty of criticism, to pass judgment for itself between alternative or conflicting views. Strictly speaking, nothing should be presented in

the form of a definition except what is, in itself, a statement of experimental facts, as for instance, we describe or define a unit of measurement in terms of other units. When dealing with a subject where more than one opinion is permissible, all should be stated, or at least, the attention should be directed to the fact that others draw different conclusions from the same premises.

The average student is better able to face issues and weigh arguments than most of us realize, and it is more important to educate those falling below the average in this particular than in any other. We should state the facts and then reason in such a way as to teach students how to think. It is indispensable for them to learn to think for themselves. Great stores of chemical facts are of but little real use, unless accompanied by an ability to adapt and to apply them in new conditions, unforeseen by either teacher or student in school or university days, but surely coming in after life. It is the prime necessity for research work or for originality of any kind, and we all are willing to admit that originality is what should be cultivated.

There is a great difference between the phrases, "elements are substances which can not be broken up" and "elements are substances which we have not as yet succeeded in breaking up," and we should mark well the difference. This caution, lest we slip into the error of stating as fact more than we really know is the distinguishing difference between the chemistry of to-day and the chemistry of a few years ago. It is more than this, it expresses concisely the difference between the way in which any science should be taught and studied, and the way in which it should be neither taught nor studied.

This particular differentiation between two definitions of the term element has been more than justified by the results which have followed the last ten years' work in pure chemistry, spectroscopy, radioactivity and Röntgenology (a term which has been seriously proposed by one of that fraternity which seems to consider its main function in life to be the coinage of new words).

The main arguments which may be marshaled in favor of considering the elements as ultimates, and the atoms as indivisible consist:

First, of all those facts which Dalton condensed into the laws of definite and multiple proportions, and to which there have been as many additions as there have been analyses and syntheses made before or since his time.

Second, Dulong and Petit's law that the atomic heats of all solid elements are the same.

Third, the isomorphism of many compounds containing similar elements, a phenomenon discovered by Mitscherlich.

Fourth, Faraday's law, that equivalent quantities of the elements are deposited at the electrodes during electrolysis.

Truly, an imposing array of evidence, and more than sufficient to justify us in making the assumption that atoms exist. But curiously

enough, there is not one item amongst all these facts compelling us to believe that these atoms are the ultimate constituents, or that they are indivisible. These later hypotheses are purely gratuitous, tacked on by Dalton and retained by succeeding chemists and physicists for no good reason. Perhaps because imitation is a characteristic, inherited from our simian ancestry and is so much easier for us than originality.

Many a chemist looks askance at any tampering with the atoms, apparently fearing that it may hurt them, or even destroy them utterly and the atomic weights with them. Or he trembles for his spidery and tenuous structural formulæ, knowing full well that if deprived of these, he will be irretrievably lost in a labyrinth, without a thread to guide him. While, if he is not permitted to think of the carbon atom as a little chunk of matter, tetrahedral in form, he thinks he is launched on a sea of troubles.

But all this apprehension arises from a misunderstanding. That the atomic weights remain unharmed and unaltered, as the units for chemical calculations, and that nothing which is good or useful about the atomic theory is destroyed or even assailed by the new ideas, that the trend of these new ideas is unmistakably constructive and not destructive, is best shown by a review of the arguments in favor of the hypothesis that the atom is divisible, and that our elements are not elements in the true sense of the word.

There is nothing new in this view; it formed the first article of the faith of the alchemists. It was unqualifiedly denied by Dalton, and fell into such disrepute that even within recent years one risked being called a dreamer, or even a fool, if he dared to consider it possible. Here again is an instance of the desirability of being as precise as possible in the use of terms. Many believe experimental evidence of the complexity of "elementary atoms" and the existence of one "mother substance" must be followed immediately by directions for transforming elements into one another; by the transmutation of baser metals into gold. But these are two wholly distinct propositions. An astronomer might locate a mountain of gold on the surface of the moon, but there would still be a goodly chasm to bridge before he derived much material benefit from his discovery!

The idea that there is one fundamental substance would not down. The hypothesis of the English physician, Prout, is a familiar one. When the atomic weight of hydrogen is set equal to unity, the atomic weights of all the other elements come out remarkably closely to whole numbers. There exist numerous groups of three elements, commonly called Döbereiner's triads, the individual members of one group being similar in their chemical properties, and so related that the atomic weight of the middle member is the arithmetic mean of the atomic weights of the extreme members. These are the facts which led Prout to suggest that there was but one element, namely, hydrogen, the others being complexes containing different quantities of this ultimate substance. It

followed that the differences between the atomic weights and whole numbers were to be ascribed to experimental errors in the determination of these values. The desire to test this hypothesis was one of the chief motives for some of the most careful determinations of atomic weights which have ever been made. These determinations resulted in proving that the divergences of the atomic weights from whole numbers was greater than could be accounted for on the basis of experimental errors. This precluded the possibility that the atom of hydrogen was the common ultimate unit, but did not dispose of the possibility that a half, or quarter, or some other fraction, of the hydrogen atom might play that rôle.

In 1901 Strutt[1] applied the mathematical methods of the theory of probabilities to the most accurately determined atomic weights, and calculated that the chance that they should fall as close to whole numbers as they do was only one in one thousand. The inference from this is that it is not a matter of chance, but that there is a regularity in the atomic weights which we do not understand; a regularity which points to the probability that our elements are complex substances, constructed according to some system, from some simpler substance.

All the facts comprised in that great generalization, the periodic law, which states that the properties of the elements, both chemical and physical, are functions of their atomic weights, and most of them are periodic functions, point unmistakably to the same conclusion.

The evidence from spectroscopic analysis is so abundant that it is not easy to compress it into a few general statements.

In the first place, the spectrum of each of our elements consists of numerous lines, a fact not exactly compatible with the notion of extreme simplicity of the particles emitting the light.

In the second place, one and the same element, contrary to common belief, frequently has two or three distinctly different spectra, the particular spectrum which appears depending upon the pressure and the temperature at which the element is, while emitting the light. In fact the extraordinary spectroscopic results obtained when highly rarefied gases enclosed in tubes (variously called Plücker, Hittorf, Geissler or Crookes tubes) were made luminous by the passage of high potential electricity, induced Crookes to suggest in 1887 a theory that the elements were all built up by gradual condensation with falling temperature from a fundamental substance to which he gave the name protyl.[2]

In the third place, the lines in the spectrum of one element may be separated out into several series. Each line corresponds, as is well known, to light of a definite wave length. The wave lengths of the lines comprised in one series are related to each other in such a way

[1] R. J. Strutt, *Philosophical Magazine*, March, 1901, p. 311.
[2] "The Genesis of the Elements," W. Crookes.

that a general formula may be derived for them. This means that, given some of the lines, the wave lengths, and thus the positions, of other lines belonging in the same series may be calculated. In this way the positions of certain lines for certain elements were foretold. Search failed to reveal all of them in light emitted by the element at any temperature producible in the laboratory. But some of the missing lines have been found in the spectra of the hottest stars, stars far hotter than our sun. At the same time many of the lines obtained by terrestrial means are lacking in the spectra of these stars. We have ample experimental evidence that many complex substances dissociate, as we call it, into less complex substances within the temperature range readily controlled in the laboratory. The inference is right at hand that at extreme, at stellar, temperatures our elements themselves are dissociated into simpler substances. To these substances, our elements, in this other condition, have been given their customary names, but with the prefix proto. Thanks to the introduction of Rowland's diffraction gratings for the study of these spectra, we have observations indicating the existence of proto hydrogen, proto calcium, proto magnesium, proto iron and so on through a list of a dozen or more "proto" elements.[8]

Continuation of the work upon which Crookes was engaged resulted in the discovery of the X-rays by Röntgen in 1895. This date may be said to mark a new era in many of our conceptions regarding the universe about us. To J. J. Thomson, professor of physics at Cambridge, England, we owe the greater part of our present knowledge of the cathode rays. He devised most of the experiments and the ingenious, but strictly logical, reasoning which justify us in supposing that these cathode rays consist of swarms of minute particles, which he called corpuscles (reviving an old term and an old theory of Isaac Newton's); particles moving with velocities approaching that of light, each one carrying a charge of what we call negative electricity. He, and those working with him, determined the quantity of this electrical charge to be the same on each corpuscle, and to be the same as the charge we have good reason to suppose is carried by any monovalent-ion in solution. By several methods the approximate number of these particles in a given volume and the weight of the individual particle were estimated. This weight appears to be about one eight-hundredth of the weight generally ascribed to the hydrogen atom, the lightest of all the atoms. It may be objected that there is no positive proof of the existence of these corpuscles, nor do we know the weight or mass of one of them. That is very true, but neither have we positive proof of the existence of atoms, nor do we know the weight of one atom. We can only say that the evidence makes the existence of these minute

[8]The methods, facts and reasonings relating to this spectroscopic evidence are interestingly given in "Inorganic Evolution," by Sir Norman Lockyer.

individuals, atoms and corpuscles, extremely plausible, and makes one as plausible as the other.

Grant that we have discovered particles—in round numbers one thousandth part the size and weight of the hydrogen atom—the argument is still not complete for the divisibility of the atom. Perhaps we have found a new element. But cathods rays were produced under circumstances where they must have arisen from the cathode itself, and it is hard to escape from the conclusion that the atoms of the cathode disintegrated to a certain extent to furnish these particles. Furthermore, rays have been studied having as their sources different metals under the influence of electrical currents, different metals heated to incandescence, flames of different kinds and ultra-violet light, and these rays appear to consist of corpuscles of the same weight no matter what their source. This makes it difficult to escape from the further conclusion that atoms of a great variety of natures are capable of disintegrating and of furnishing the same product by the disintegration[4]; and this is as much as to say that instead of about eighty different elements we have one "mother substance" and Prout's hypothesis is once more very much alive, somewhat modified it is true and in a new garb, better suited to the present fashions.

It remains to rehearse briefly the evidence to be obtained from radio-active phenomena. In the first place, the rays incessantly sent out from these extraordinary substances consist, at least in part, of rays like the cathode rays, and are streams of the same kind of corpuscles but, on the whole, traveling with greater velocities than the corpuscles of the cathode rays. It has been proved by Rutherford and Soddy that the emission of the radiations from these substances is accompanied by a disintegration, or decay as they describe it, of the substances themselves. These investigators have caught some of the products of this decay and have studied their properties. These products themselves decay, some slowly, some rapidly, sending forth other rays and furnishing new products to decay in turn. Indeed each new issue of a scientific journal for the past few years seems to chronicle the birth, life and death of a fresh radio-active substance. The rate at which new offspring of radium, thorium and allied elements are discovered and studied during their fleeting existences reminds one of nothing so much as the genealogy of Noah, as given in the fifth chapter of Genesis[5].

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[4]Experimental details, and also comprehensive treatments of the subject as a whole and of special parts may be found in three books by J. J. Thomson: "The Discharge of Electricity Through Gases" (based on lectures given at the University of Princeton in October, 1896): "Condition of Electricity Through Gases" (a larger book); "Electricity and Matter" (lectures delivered at Yale University in 1903).

[5]It is an indication of the widespread interest in this subject, and of the activity of the workers in this field, that one journal, in the year 1905, contained no less than 167 abstracts of articles upon radioactive phenomena. E. Rutherford's book, "Radioactivity," 2nd edition, 1905, is a masterly survey of the whole subject.

These products appear to be elements, and this idea that some elements may have existences of but short duration, from a few seconds to many years, is a decidedly novel one. It has been suggested that this may account for some of the vacant spaces in our periodic table of the elements, particularly in the neighborhood of thorium, radium and uranium. Perhaps these spaces never will be occupied except by transients. Indeed it is not impossible that all our elements are mere transients, mere conditions of things, all undergoing change. But there is no immediate danger of their all vanishing away in the form of rays and emanations. Rutherford has calculated that radium will be half transformed in about 1,300 years, that uranium will be half transformed in 6×10^{9} years, and thorium in about 2.4×19^{9} years. We may safely say the other elements are decaying much more slowly, so we may continue to direct our anxieties towards the probable duration of our coal beds and deposits of iron ore as matters of more present concern.

The objection may be raised that perhaps radium should not be classed as an element, but rather should be considered as an unstable compound in the act of breaking down into its elements. But the answer to this objection is at hand. The evolution of energy accompanying these changes is far in excess of that obtainable from any known chemical process, so far in excess that it is certain we are dealing with a source of energy hitherto unknown to us, with a wholly new class of phenomena. The following quotation from Whetham[6] will convey an adequate conception of the magnitude of the forces at work here.

"It is possible to determine the mass and the velocity of the projected particles, and, therefore, to calculate their kinetic energy. From the principles of the molecular theory, we know that the number of atoms in a gramme of a solid material is about 10^{20}. Four or five successive stages in the disintegration of radium have been recognized, and on the assumption that each of these involves the emission of only one particle, the total energy of radiation which one gramme of radium could furnish if entirely disintegrated seems to be enough to raise the temperature of 10^{8} grammes, or about 100 tons of water through one degree centigrade. This is an underestimate; it is possible that it should be increased ten or a hundred times. As a mean value, we may say that, in mechanical units, the energy available for radiation in one ounce of radium is sufficient to raise a weight of something like ten thousand tons one mile high."

Again,

"the energy liberated by a given amount of radioactive change . . . is at least 500,000 times and may be 10,000,000 times, greater than that involved in the most energetic chemical action known."

The theory that the source of most of the sun's energy is a decay of elements analogous to radium, to disintegration of atoms, is acknowledged to account better than any previous theory for the great quantity of this energy which we observe, and for the length of time during which it must have been given off according to the evidences of geology.

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[6] "The Recent Development of Physical Science," W. C. D. Whetham.

There is no chemical reaction which is not hastened or retarded by a change in temperature. In general, the velocity of a chemical reaction is increased by an elevation of the temperature and diminished by a reduction of the temperature. But radium compounds emit their rays undisturbed, at an even, unaltered rate, whether they be heated to a high temperature, or cooled by immersion in liquid hydrogen; and what is perhaps equally striking, whether they are in the solid state or dissolved in some solvent.

In view of such facts as these it is idle to suppose that radium is an unstable compound decomposing into its elements, using the terms compound and element in their usual sense. Conflict as it may with preconceived opinions, we seem forced to concede, not only that the transmutation of the elements is possible, but also that these transmutations are going on under our very eyes.

As has already been pointed out, this does not mean that we shall shortly be able to convert our elements into each other. Far from it, up to the present time we have not the slightest idea how to initiate such a process nor how to stop it. We can not, by any means known to us, even alter the rate at which it proceeds.

Now how shall we fit all these new facts and ideas in with our old ones regarding the elements and atoms, and how many of the old ideas must be discarded? Brief consideration is enough to convince us that very few of the old ideas, in fact none of value, need be sacrificed. We must indeed grant that Dalton's fundamental assumption is false, that the atom, in spite of its name, is divisible and consequently that our elements are not our simplest substances, but decidedly complicated complexes. But all the facts included in the laws of definite and multiple proportions remain fixed and reliable, as indeed must all facts, expressions of actual experimental results, no matter what else varies. And there is not the least necessity for altering the methods of using atomic weights in calculations, nor for ceasing to use structural diagrams and models for molecules. We must merely modify our ideas and definition of an atom, and this modification is in the direction of an advance. We know more about an atom, or think we do.

Assume the inferences from the evidence just reviewed to be correct, and how do they affect our conception of the atom? First of all, our smallest, lightest, simplest atom, that of hydrogen, becomes an aggregation of about eight hundred smaller particles or corpuscles, and the atoms of other elements become aggregations of as many corpuscles as are obtained by multiplying the atomic weight of the element by eight hundred. Thus the atom of mercury must be thought of as containing 800 times 200 or 160,000 corpuscles. Next, the methods by which we believe we can calculate the approximate size of atoms and corpuscles gives us values which enable us to make such comparisons as the following suggested by Sir Oliver Lodge: "The corpuscle is so small as compared to the atom that it, within the atom, may be likened to a mouse

in a cathedral," or "the corpuscle is to the whole atom as the earth and other planets are to the whole solar system."

These corpuscles are probably gyrating about each other, or about some common center, with velocities approaching that of light. It seems needful to suppose this, for it is hard to imagine that the enormous velocities observed could be imparted to a corpuscle at the instant it leaves the atom to become a constituent of a cathode ray. It is more reasonable to imagine that the corpuscle already had this velocity and that it flew off at a tangent owing to some influence we do not understand.

This may appear, after all, to be little more than pushing back our questions one stage, so that the position occupied in our thoughts but yesterday by the atom, is now occupied by the corpuscle. Quite true, but this is in itself a great step, for the advancement of knowledge consists of nothing else than such pushing back of the boundaries. We dare not assume the end is reached, for there is no proof that the corpuscles are ultimate. They mark the present limit of our imaginings based on experiment, but no one can say but what the next century may possibly witness the shattering of the corpuscles into as many parts as it now appears to take to make an atom.

The question is a legitimate one, do we know any more about these "new fangled" corpuscles than we did about the old atoms? The answer is, yes, we probably do. We can go farther in our reasoning on the basis of the properties of the corpuscles, and arrive at results which are startling when heard for the first time.

Lenard[7] has shown that the absorption of cathode rays by different substances is simply proportional to the specific gravity of those substances and independent of their chemical properties. It is even independent of the condition of aggregation, *i. e.,* whether the absorbing substance be investigated as a gas, as a liquid or as a solid. This is another strong argument in favor of the view that there is but one "mother substance" which consists of corpuscles. The corpuscles of the cathode rays must be considered as passing unimpeded through the interstices between the corpuscles of the atom. Lenard calls the corpuscles dynamides and considers them as fields of electrical force with impenetrable central bodies which then constitute actual matter. He calculates the diameter of this center of actual matter as smaller than 0.3×10^{-10}(=0.000,000,000,03) millimeter. Applying these results to the case of the metal platinum, one of the most dense of the metals, one of those with the highest specific gravity, he concludes that a solid cubic meter of platinum is in truth an empty space, with the exception of, at the outside, one cubic millimeter occupied by the actual matter of the dynamides.

If we can thus reasonably and mathematically eliminate the matter

[7] *Wied. Annal.*, 56, p. 255 (1895), and *Drudes Annal.*, 12, 714 (1903).

of a cubic meter of one of our densest metals to such an extent, it should not be very difficult to make one more effort and eliminate that insignificant little cubic millimeter still remaining, and say, with cogent reasons behind us for the statement, that there is no matter at all, but simply energy in motion. This is exactly what has been done by many who occupy high and authoritative positions in the scientific world.

Long before experimental evidence of the existence of corpuscles had been obtained, it was demonstrated that an electrically charged body, moving with high velocity, had an apparent mass greater than its true mass, because of the electrical charge. The faster it moved the greater became its apparent mass or, what comes to the same thing, assuming the electrical charge to remain unaltered, the greater the velocity, the less the mass of the body carrying the charge needed to be to have always the same apparent mass. It was calculated that when the velocity equaled that of light, it was not necessary to assume that the body carrying the charge had any mass at all! In other words, the bit of electric charge moving with the velocity of light, would have weight and all the properties of mass.

This might be looked upon as an interesting mathematical abstraction, but without any practical application, if it were not for the fact that Kaufmann[8] determined the apparent masses of corpuscles shot out from a radium preparation at different velocities, and compared them with the masses calculated on the basis that the whole of the mass was due to the electric charge. The agreement between the observed and calculated values is so close that it leads Thomson to say: "These results support the view that the *whole* mass of these electrified particles arises from their charge."[9]

Then the corpuscles are to be looked upon as nothing but bits of electric charge, not attached to matter at all, just bits of electric charge, nothing more nor less. It is this view which has led to the introduction of the term electron, first proposed by Stoney, to indicate in the name itself the immaterial nature of these ultimates of our present knowledge. We have but to concede the logical sequence of this reasoning, all based on experimental evidence, and the last stronghold of the materialists is carried, and we have a universe of energy in which matter has no necessary part.

If we accept the electron theory, our atoms are to be considered as consisting of bits of electric charge in rapid motion, owing their special properties to the number of such bits within them, and also, no doubt, to the particular orbits described by the electrons. If space permitted it would be interesting to show how admirably the periodicity of the properties of the elements, as expressed in Mendelejeff's table,

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[8] *Phys. Zeitschr.*, 1902, p. 54.
[9] "Electricity and Matter," p. 48.

can be accounted for on the basis of an increasing number of like electrons constituting the atoms of the successive elements. We have molecules consisting, at the simplest, of two such systems within the sphere of each other's attraction, perhaps something as we have double stars in the heavens.

A possible explanation of the puzzling property of valence is offered, in that an atom less one electron, or plus one electron, may be considered as electrically charged, and therefore capable of attracting other bodies, oppositely charged, to form electrically neutral systems. An atom less two electrons, or with two electrons in excess, would have twice the ability to combine, it would be what we call divalent, and so on. An electronic structure of the atom furnishes a basis from which a plausible explanation of the refraction, polarization and rotation of the plane of polarized light may be logically derived. Hitherto explanations for the observed facts have been either wanting or more or less unsatisfactory. For instance, grant the actual existence of tetrahedral carbon atoms, with different groups, symmetrically arranged at the apices, and yet we can not see any good and valid reason *why* such a structure should be able to rotate the plane of polarized light. Grant that the molecule consists of systems of corpuscles traveling in well-defined orbits, and we see at once how light, consisting of other electrons of the same kind, traversing this maze *must* be influenced.

Adopting this theory of corpuscles or electrons, not a concept of any value need be abandoned. On the contrary, the theory furnishes us with plausible explanations of many facts previously unexplained. Its influence is all in a forward direction, toward a simplification and unification of our knowledge of nature.

A few words must be said regarding the old, the threadbare, argument which, of course, is cited against the electron theory. The materialist says he simply can not accept a theory which obliges him to give up the idea of the existence of matter; he says the table is there because he can see it and feel it and that must end the discussion for any one with common sense and moderately good judgment. Now it is the reverse of common sense to let that end the discussion, and our materialist is pluming himself on precisely those qualities which he most conspicuously lacks. He assumes the obnoxious theory to involve consequences which it does not involve and then condemns it because of those consequences. As a rule it is because he knows little about it, and has thought less, that he assumes the electron theory to be pure idealism in an ingenious disguise, that form of idealism which asserts that there is no universe outside ourselves and that everything is a figment of the imagination of the observer. The electron theory postulates a universe of energy outside ourselves. It does not deny the existence of the table; quite the reverse, it asserts it and then offers a detailed description of it, and why it has the properties which it has. This is more than any materialistic theory can do. The electron theory

affirms the existence of what we ordinarily call matter. It defines, describes, explains these things, ordinarily called matter, in a clear and logical manner, on the basis of experimental evidence, as a *mode of motion.* It opposes the use of the word matter, solely because that word has come to stand, not only for the object, but also for the assumption that there is something there which is not energy.

Another groundless objection is offered by the materialists. They say this electron theory is clever, perhaps plausible, but very vague and hopelessly theoretical. Of course it is theoretical, but it is a theory more intimately connected with experimental facts than any other theory regarding the ultimate constituents. One departs further from known facts in assuming the existence of a something to be called matter. What is this matter which so many insist that we must assume? No one can define it otherwise than in terms of energy. But forms of energy are not matter as the materialist understands the word. Starting with any object and removing one by one its properties, indubitably forms of energy, we are finally left with a blank, a sort of a hole in creation, which the imagination is totally unable to fill in. The last resort is the time-honored definition, "matter is the carrier of energy," but it is impossible to describe it. The assumption that matter exists is made then because there must be a carrier of energy. But why must there be a carrier of energy? This is an assertion, pure and simple, with no experimental backing. Before we have a right to make it we should obtain some matter "strictly pure" and free from any energy, or, at least, we should be able to demonstrate on some object what part of it is the energy and what part the matter, the carrier of the energy. We have not done this, we have never demonstrated anything but forms of energy, and so we have no evidence that there is any such thing as matter. To say that it exists is theorizing without experimental evidence as a basis. The materialistic theory postulates energy and also matter, both theoretical if you will, the electron theory postulates energy only. Therefore the electron theory is the less theoretical and the less vague of the two.

From the philosophical standpoint, having deprived an object of all that we know about it, all forms of energy, there remains what may be called the "residuum of the unknown." We are not justified in saying that nothing remains; we can only say nothing remains which affects, either directly or indirectly, any of our senses through which we become cognizant of the external universe. If the materialist takes the stand that this unknown residuum is what he calls matter, although any other name would be equally appropriate, it must be acknowledged that his position is at present impregnable, and that sort of matter exists. But it is nothing with which experimental science can deal. A fair statement would appear to be: The electron theory accounts for, or may be made to account for, all known facts.

Besides these there is a vast unknown within whose precincts matter may or may not exist.

Michael Faraday is acknowledged to have been one of the ablest of experimenters and clearest of thinkers. His predominant characteristic may be said to be the caution which he used in expressing views reaching beyond the domain of experimental facts. His authority rightly carries great weight and it is therefore of particular significance that he expressed himself more definitely upon these questions than appears to be generally known. In an article published in 1844[10] he says:

"If we must assume at all, as indeed in a branch of knowledge like the present we can hardly help it, then the safest course appears to be to assume as little as possible, and in that respect the atoms of Boscovich appear to me to have a great advantage over the more usual notion. His atoms, if I understand aright, are mere centers of forces or powers, not particles of matter, in which the powers themselves reside. If, in the ordinary view of atoms, we call the particle of matter away from the powers *a*, and the system of powers or forces in and around it *m*, then in Boscovich's theory *a* disappears, or is a mere mathematical point, whilst in the usual notion it is a little unchangeable, impenetrable piece of matter, and *m* is an atmosphere of force grouped around it. . . . To my mind, therefore, the *a* or nucleus vanishes, and the substance consists of the powers or *m;* and indeed what notion can we form of the nucleus independent of its powers? All our perception and knowledge of the atom, and even our fancy, is limited to ideas of its powers: what thought remains on which to hang the imagination of an *a* independent of the acknowledged forces? A mind just entering on the subject may consider it difficult to think of the powers of matter independent of a separate something to be called *the matter*, but it is certainly far more difficult, and indeed impossible, to think of or imagine that *matter* independent of the powers. Now the powers we know and recognize in every phenomenon of the creation, the abstract matter in none; why then assume the existence of that of which we are ignorant, which we can not conceive, and for which there is no philosophical necessity?"

There is a striking analogy between the present condition of our science and our discussions, and those prevailing in the latter half of the eighteenth century when the phlogiston theory was almost universally accepted. We all now believe that heat is a mode of motion and smile at the thought that there were those who considered heat as a material. The materialistic theory is the phlogiston theory of our day and perhaps the time is not far distant when the same indulgent smile will be provoked by the thought that there were those unwilling to believe that matter is a mode of motion.

REFERENCE LIBRARY FOR CHEMISTRY

PROFESSOR B. W. PEET, MICHIGAN STATE NORMAL COLLEGE

The following list of books is submitted as a basis for a chemical library for high schools. The titles mentioned have been selected in the main with reference to the needs of the teacher, although a number are also adapted to the use of the pupils. The books have been

[10]"Experimental Researches in Electricity," Michael Faraday, Vol. 2, pp. 289-91.

classified and only a comparatively few are placed under each heading. It seemed advisable to limit the number yet include the most of the best books published. The list has been submitted to several university professors and high school teachers of chemistry and has in general met their approval.

Beginning students can make little use of reference books until they have acquired some knowledge of the general principles of chemistry, so it is recommended that students not be asked to make any special study of reference books until the second half of the first year's work.

BIBLIOGRAPHY.

I. HIGH SCHOOL TEXTS.

Essentials of Chemistry, Hesseler and Smith. 405 pages. Benj. H. Sanborn & Co., Chicago	$ 1.20
Descriptive Chemistry, Newell. 590 pages. D. C. Heath & Co.	1.20
Elementary Chemistry, Linebarger. Rand, McNally & Co.	1.00
Elementary Chemistry, Bradbury. 486 pages. D. Appleton & Co.	1.20
Modern Chemistry, Peters. 412 pages. Maynard, Merrill & Co.	1.00
Introduction to the Study of Chemistry, Remsen. (New edition, 1906.) 516 pages. (Briefer course). Henry Holt & Co.	1.12
Elementary Inorganic Chemistry, Newth. 288 pages. Longmans, Green & Co.	.90
Experimental Chemistry, Newell. 410 pages. D. C. Heath & Co.	1.10
Elementary Principles of Chemistry, Young. 358 pages. D. Appleton & Co.	1.20
Elementary Manual of Chemistry, Storer and Lindsay. 453 pages. American Book Co.	1.20

II. LARGE DESCRIPTIVE.

An Introduction to General Inorganic Chemistry, Alex. Smith. pp. XVIII plus 780. Century Co.	$ 2.25
Outlines of Inorganic Chemistry, Gooch and Walker. 514 pages. Macmillan Co.	1.75
Text-Book of Inorganic Chemistry, Newth. 602 pages. Longmans, Green & Co.	1.75
Text-Book of Inorganic Chemistry, Holleman. 458 pages. John Wiley & Sons	2.50
Inorganic Chemistry, Advanced Course, Remsen. 850 pages. Henry Holt & Co.	2.80
General Inorganic Chemistry, Freer. 559 pages. Allyn & Bacon, Boston.	3.00
The Principles of Inorganic Chemistry, Ostwald. Translated by Alexander Findlay. 785 pages. Macmillan Co.	6.00
Treatise on Chemistry, Roscoe and Schorlemmer, Vols. I and II. New edition. (Inorganic.) D. Appleton & Co.	8.00

III. ANALYTICAL.

Qualitative Chemical Analysis, Prescott and Johnson. 420 pages. D. Van Nostrand Co., New York	$ 3.50
Qualitative Chemical Analysis, A. A. Noyes. 89 pages. MacMillan Co.	1.25
The Principles of Qualitative Analysis from the Standpoint of the Theory of Electrolytic Dissociation and the Law of Mass Action, Dr. Wilhelm Boettger. Translated by Wm. G. Smeston. P. Blakiston's Son & Co. Out soon.	
Analytical Chemistry; Qualitative Analysis, Treadwell. Translated by Hall. 466 pages. John Wiley & Sons	3.00
Quantitative Chemical Analysis, Olsen. 513 pages. D. Van Nostrand Co., New York	4.00
Quantitative Chemical Analysis, Clowes and Coleman. 602 pages. P. Blakiston Co., Philadelphia	3.50
Analytical Chemistry. Quantitative Analysis, Treadwell. Translated by Wm. Hall. 654 pages	4.00

IV. DICTIONARIES.

Dictionary of Chemistry, Watts. 4 Vols. Longmans, Green & Co..... $65.00
A Dictionary of Chemical Solubilities, Comey. 515 pages. Macmillan Co..... 5.00
The Chemists' Pocket Manual. Chemical Pub. Co., Easton, Pa..... 2.00

V. THEORETICAL AND PHYSICAL.

Introduction to Physical Chemistry, Walker. 332 pages. Macmillan & Co..... $ 2.50
The Elements of Physical Chemistry, Jones. Macmillan Co..... 4.00
Chemical Theory for Beginners, Dobbin & Walker. 236 pages. Macmillan Co. .70
Physical Chemistry for Beginners, VanDeventer. Translated by Boltwood. 154 pages. John Wiley & Sons, New York..... 1.50
Theoretical Chemistry, from standpoint of Avogadro's Rule, Nernst. Macmillan Co. 5.00
Elements of Physical Chemistry, Morgan. John Wiley & Sons..... 2.00

VI. HISTORICAL.

History of Chemistry, Von Meyer. Translated by McGowan. 544 pages. Macmillan Co. ..... $ 4.50
History of Chemistry, Venable. 172 pages. D. C. Heath & Co..... 1.00
Heroes of Science—Chemists, Muir. 350 pages. Thomas Nelson & Son..... 1.50
History of Chemistry, Landenburg. Translated by Dobbin. 373 pages. University of Chicago Press 1.75
Essays in Historical Chemistry, Thorpe. 381 pages. Macmillan Co..... 2.25

VII. ORGANIC.

Organic Chemistry, Perkin and Kipping. 552 pages (2 vols.) J. D. Lippincott Co., Philadelphia ..... $ 2.00
Organic Chemistry, Remsen. 364 pages. D. C. Heath & Co..... 1.30
Organic Chemistry, Richter-Smith. (2 vols.) P. Blakiston Co., Philadelphia.. 6.00

VIII. MISCELLANEOUS.

Outlines of Industrial Chemistry, F. H. Thorp. 528 pages. Macmillan Co..... $ 3.30
Methods of Glass Blowing, Shenstone. 96 pages. Longmans, Green & Co..... .50
Chemistry of Daily Life, Lasser-Cohn. J. B. Lippincott Co..... 1.75
The Teaching of Chemistry and Physics, Smith & Hall. 377 pages. Longmans, Green & Co. 1.50
Chemical Lecture Experiments, Benedict. 476 pages. Macmillan..... $ 2.00
Conversations on Chemistry, Part I, Ostwald. Translated by Elizabeth Ramsey. John Wiley & Sons. 250 pages 1.50
Conversations on Chemistry, Part II. Translated by S. K. Turnbull. 373 pages. Wiley & Sons 1.50
Chemistry of Plant and Animal Life, Snyder. 406 pages. Macmillan Co..... 1.40
Story of a Piece of Coal, Martin. 165 pages. D. Appleton & Co..... .40

IX. PERIODIQALS.

School Science, 440 Kenwood Terrace, Chicago. Monthly. October to June, inclusive ..... $ 2.00 per year
Journal of the American Chemical Society, Eschenbach Printing Co., Easton, Pa. Monthly ..... 6.00 per year
Science, 41 North Queen St., Lancaster, Pa., or 66 Fifth Ave., New York. Weekly ..... 5.00 per year
Science Abstracts .....
Engineering Index .....
Scientific American .....

DISCUSSION OF LIST

A few of the recently published high school texts are very valuable reference books for students to use along with their own text, and they can usually be obtained for such purpose gratis of the publishers.

LARGE DESCRIPTIVE

The most useful and extensive work of reference is the inorganic portion of Roscoe and Schorlemmer's Treatise on Chemistry. It deals with the historical, descriptive and theoretical parts of nearly all chemical subjects. The first two volumes have recently been revised.

The other books mentioned under "Large Descriptive" are university texts. Newth is noted for its attention to industries, Holleman for the interweaving of the Electrolytic Dissociation Theory with the descriptive and theoretical part in a simple way, Remsen and Freer for lucidity and discussion of general relations. The tables of comparisons of the elements in the various families and the discussion of the periodic law are well represented in Freer. Ostwald's Principles of Inorganic Chemistry is a modern classic and should be in the hands of every teacher who can afford it. The new notions and theories of scientific chemistry are very cleverly presented. The author has taken particular care in the development of the conception of ions. It is a text book of *pure* chemistry, so little attention is given to the related sciences and arts.

Every teacher of chemistry should have access to Alexander Smith's Introduction to General Inorganic Chemistry (just published). It is full of good ideas and methods of teaching different subjects. The chapters on Solution, Chemical Equilibrium, Dissociation in Solution, Electrolysis, Chemical Behavior of Ionic Substances are intensely interesting and well written. The theoretical side of chemistry is as clearly presented here as in any book on the market and it is up to date. The book contains about eighty pages of matter in smaller type which is especially for teachers and contains discussions of many points upon which teachers find difficulty in getting information, and also discussion of subjects upon which teachers are apt to go astray.

ANALYTICAL

Prescott & Johnson's book is noted for the number of balanced equations and explanations of chemical reactions. Treadwell's Qualitative Analysis is a recent book and is generally considered an excellent one. The descriptions of the operations are full and clear, the equations are very fully treated and the treatment of acids is unusually extensive. The author utilizes the theory of electrolytic dissociation, mass action and hydrolysis, and explains their relations to analysis. Fresenius was long considered the best text book on Qualitative Analysis, but it is not now generally thought of as up to date, so it is not included in the list. One of the most recent books on qualitative analysis is Boettger's, now being translated by Wm. G. Smeaton of the University of Michigan. It makes practical application of the dissociation theory in the study of the metals.

If one wishes a book on quantitative analysis that describes methods of manipulation in detail and at the same time includes a com-

pilation of the best methods of analysis, both Olsen and Clowes and Coleman are highly recommended. Olsen is more recent and seems to be the favorite in this country so far as it is known. In the back part of the book are chapters on water, gas, coal, iron and steel analysis.

DICTIONARIES

Watt's Dictionary of four volumes contains articles, varying in length from a few lines to several pages, on nearly every chemical substance and every topic in scientific chemistry. It is often convenient to have a reference book on the solubility of chemical compounds to check results obtained by experiments in the laboratory or to aid one in making up solutions. Comey's dictionary is recommended. Meade's Pocket Manual contains many valuable tables and much general information.

THEORETICAL AND PHYSICAL

The books on Theoretical and Physical Chemistry are recommended for the use of the teachers of chemistry only. All that is necessary for students' use can be found in any good college text-book such as Alexander Smith's or Holleman's. Walker's Physical Chemistry is clear and more easily understood than most of the books on the market. The revised edition of Morgan is also very readable and a general favorite. Dobbin and Walker and VanDeventor are elementary. Jones is more complete, not so easy to comprehend but a very valuable reference book.

HISTORICAL

No chemical library would be complete without some book on historical chemistry. A fund of information can be obtained here for making the every day lessons interesting. The teacher as well as the pupil will get a more comprehensive view of chemistry by knowing the struggles and failures and triumphs of the men who have made the science for us.

A very satisfactory book is Ladenburg's, translated by Dobbin. It is a compilation of a course of lectures, and is presented in an interesting style. If one wishes a more complete treatise, VonMeyer is excellent. A very brief but reliable history of chemistry is Venable's. Heroes of Science by Muir, and Essays in Historical Chemistry by Thorpe take up only a few subjects but they both read like romance and the pupil, as well as the teacher, will read them with delight.

ORGANIC

A very satisfactory reference book on Organic Chemistry is Perkin & Kipping's. Remsen is very good, but it is often so brief that parts are not easily understood. Remsen is desirable, however, because it is so full of easy experiments to illustrate many subjects. A very comprehensive view of the carbon compounds is to be found in Richter-

Smith's book. The student and the teacher, with little preparation in organic chemistry, will probably get the most satisfaction from Perkin & Kipping's two volumes.

MISCELLANEOUS

The industrial or practical side of chemistry always appeals to the average student. Thorp's book seems to be a general favorite. It requires but little encouragement to make the pupils anxious to read about the great chemical industries, such as the manufacture of soap, cooking soda, sulphuric acid and the metallurgy of iron. This book should be in every chemical library.

The Chemistry of Daily Life by Lasser-Cohn and The Chemistry of Plant and Animal Life by Snyder are intensely interesting and practical. The latter book deals with the chemistry of digestion, of foods and the rational feeding of animals, including men.

Every wide-awake teacher should have access to the Teaching of Chemistry and Physics, by Smith and Hall. It is full of suggestions on instruction in the class room and laboratory, tells how to present many difficult subjects and discusses the equipment of laboratories and lecture room.

Conversations on Chemistry, volumes 1 and 2, by Ostwald, are written in the form of a dialogue between the master and pupil. The teacher will get valuable ideas of presenting many difficult subjects to his students by reading these books. He is taught to realize the hard things from the pupils' standpoint.

It will add much interest to the development of any subject to illustrate it with other experiments than the ones given in the text or laboratory manual. Some such reference book as Benedict's Chemical Lecture Experiments is very desirable. It is full of interesting experiments on most topics in inorganic chemistry.

The best way to keep in touch with what is going on in the chemical world is to read at least one journal. The Journal of the American Chemical Society is highly recommended because of the review given in each number of the leading articles appearing in different journals and also the mention and review of the books published on chemistry.

School Science contains articles on all branches of science taught in the public schools, including mathematics. It is a magazine especially for the teachers of high schools, and no high school library should be without it. In addition to the valuable and often very practical articles written by university professors and high school teachers of prominence, brief reports of the science meetings in various parts of the United States are given.

The busy science teacher is too often satisfied to confine himself to the texts in use and pays little attention to what is being done in the scientific world. No progressive teacher, no matter what his salary may be, can afford to be without access to some science journal. It gives him inspiration to do better work, it keeps his mind more

active, it helps more than any one thing to keep him out of a rut. It is not so important what journal the teacher reads, but read some good one and keep in touch with the scientific spirit of the time.

In conclusion let me emphasize that the teacher of chemistry cannot do his duty unless he has access to at least one good reference book in each of the main branches into which the science is divided, namely; inorganic, organic, analytical, historical, physical and industrial, and also reads some good science journal.

AN EXPERIMENT TO DETERMINE THE EQUIVALENT WEIGHT OF MAGNESIUM.

RICHARD R. PUTNAM, EASTERN HIGH SCHOOL, DETROIT.

In this experiment any form of alkalimeter may be used. The whole experiment is carried out exactly as in the determination of carbon dioxide with the same instrument. About 0.5 g. of magnesium is put into the alkalimeter along with a little water. The acid used is concentrated sulphuric.

If the results of this experiment are used in connection with those of the experiment described by Mr. Clemens, it is obvious that the volume of 1 g. of hydrogen, and the weight of 1 litre of hydrogen can be calculated.

A SERIES OF COMBINING WEIGHT DETERMINATIONS.

JOHN WALKER MATTHEWS, WESTERN HIGH SCHOOL, DETROIT.

This series of experiments gives the pupil a good practical idea of the different ways in which the equivalent weights of the elements are determined and fixes, also, the fact in the mind that much care and patience is necessary in getting anything like quantitative results in laboratory work.

The pupil first determines the equivalent weight of sodium by replacing one atom of hydrogen of water with the metal sodium. This is done by first filling an 100 c.c graduate with water and inverting over water in the pneumatic trough. Next he weighs a bright piece of sodium, say .11 gr., and wraps it in wire gauze and inserts it in under the graduate in the pneumatic trough. The volume of gas in the graduate reduced to standard conditions of temperature and pressure was found to be 53.8 c.c. Reducing this volume to weight gives .00482 gr. Then from the proportion .00482:.11:1:x. he obtains

22.71 as the equivalent weight of sodium. The true weight, H. as standard, is 22.88, or 23 for practical purposes.

He is next required to determine the equivalent weight of zinc by replacing the hydrogen of hydrochloric acid. The zinc foil used was found to contain about 8½% of foreign matter, hence this per cent. of weight was deducted from the first weight .295 gr. which leaves .27 gr. of zinc. The 100 c.c. graduate was again filled over the pneumatic trough and then a large test tube was filled with 30% hydrochloric acid and the zinc introduced into the acid and the delivery tube placed under the graduate. The volume of hydrogen then reduced to standard conditions and weight gave .00837 gr. Forming the proportion .00837:27::1:x the equivalent weight of zinc was found to be 32.2.

The next experiment was to find the equivalent weight of silver by substituting the known zinc in place of the silver of silver nitrate. The zinc was weighed out as before and the foreign matter deducted which left .44 gr. Placing the zinc in a test tube and adding the strong solution of silver nitrate it was left until all of the zinc had disappeared. Then it was washed through several waters and the solution decanted in order to remove the excess of silver nitrate leaving the silver precipitate. This was placed into the drying oven and heated to 220° C. for 40 minutes, allowed to cool and weighed. Deducting the weight of test tube and foreign matter the silver was found to weigh 1.47 gr. Forming the proportion .44:1.47: :32.2:x the equivalent weight of silver was found to be 107.5.

Of course there are many chances for the pupil to make errors and it does not take much of an error to throw the result off enough to make the experiment of no quantitative value, yet there is much to gain in working such experiments for the qualitative value. I am of the opinion that we are wasting much time and energy of pupils and teachers in requiring High School pupils to try to determine very many quantitative results during the first semester of work in chemistry. What quantitative work is done should be in the second semester, and that of such nature as would lead to general principles, and not of a technical nature. There should be more interest aroused in the pupils for the subject of chemistry itself, and not to be taken as mere filling out of course and hours' credit. Such topics as the "Bread We Eat," "Digestion of Foods," "Manufacture of Baking Powder," "Soap," "Gas," "Dyestuff," "Paints," etc., and more time given to the identification of elements would tend to bring out this interest.

As chemistry is taught in the high school today it leads to nothing and counts for nothing. The pupil having had a year of the subject goes to college and is not recognized as having had any of the subject, but takes the same work as the pupil entering without chemistry. There is wrong somewhere. Either the teachers of chemistry are not worthy the name or the pupil is wasting time, and it would

seem to be a good subject to discuss in a meeting like this to find out where the wrong is.

It also seems wrong to me to spend so much time in sciences in the high school for preparing pupils for college entrance to the detriment of those who do not go to college. This is not only true of chemistry but of physics and botany also. Our high school physics is applied mathematics, and our botany a course with the microscope. This is all right for one-tenth, say, of our pupils, but nine-tenths of them do not and can not become interested in so much technical work.

A METHOD OF CLASSIFYING THE INORGANIC ACIDS FOR ANALYSIS.

W. S. LEAVENWORTH, OLIVET COLLEGE.

It is safe to assert that an entirely satisfactory method for the analysis of the acids is yet to be formulated. The following method is one which I have used with my students in a more or less modified form for several years with good results, and I venture to present it, thinking it may interest those who are teachers of chemistry.

As we all know the separation of the acids is not as easily effected as the separation of the bases, since their grouping is not so distinct and since they are not so readily separated by precipitation and filtration.

In this classification the groups of the acids are successively precipitated and separated by the use of solutions of the salts of an organic acid, thus eliminating the use of an inorganic acid. This method includes the detection of some twenty inorganic and a few organic acids.

PREPARATION OF THE SOLUTION

If necessary treat the solution with H_2S to remove the metals of the first two groups. Filter, boil to expel H_2S gas from the filtrate and add a slight excess of Na_2CO_3.

Boil, filter while hot, wash and reserve the precipitate which may contain silicic, phosphoric and oxalic acids.

The filtrate contains all the acids present except the silicates, phosphates, oxalates and perhaps the fluorides. While still hot expel from the filtrate the excess of CO_2 by acidifying with acetic acid and finally neutralize the solution with the least possible amount of NH_4OH.

EXAMINATION OF THE NA_2CO_3 PRECIPITATE FOR SILICIC, PHOSPHORIC, AND OXALIC ACIDS

Treat one portion of the precipitate with HNO_3 and evaporate the solution to dryness. Digest the residue with water, add HNO_3, and filter. A white, gritty powder which, when fused in a bead of "micro-

cosmic salt," dissolves and floats in the bead, shows the presence of silicic acid.

To the above filtrate add an excess of ammonium molybdate in nitric acid, warm and let the test stand. The formation of yellow crystalline ammonium phosphomolybdate, shows the presence of phosphoric acid.

Treat another portion of the precipitate with acetic acid and filter to remove any insoluble residue. Boil the filtrate to remove all traces of CO_2 and then add $CaSO_4$ or $CaCl_2$. A white powdery precipitate shows the presence of oxalic acid. If a fluoride were present the precipitate with these reagents would be gelatinous and nearly colorless.

If silicates and fluorides are both present ,they will likely combine forming either silicon fluorides or hydrofluosilicic acid.

GROUPS OF THE ACIDS

Group I

Acids decomposed by the stable mineral acids with the evolution of a gas.

Carbonic—Evolves CO_2, which clouds lime water.
Sulphurous—Evolves SO_2, which has the odor of burning sulphur.
Nitrous—Evolves NO, which forms brown fumes with the air.
Hydrosulphuric—Evolves H_2S, which has a stale-egg odor.
Hydrocyanic—Evolves HCN, which has a bitter almond odor.
Acetic—Evolves $C_2H_4O_2$ with H_2SO_4, and forms a red solution with FeC_3.

Group II

Acids precipitated from neutral solutions by Calcium Acetate:

Arsenious—White, soluble in excess or in acetic acid.
Boric—White, soluble in excess or in acetic acid.
Carbonic—White, soluble in acetic acid with effervescence.
Hydrocyanic—White, soluble in excess or in acetic acid.
Phosphoric—White, soluble in acetic acid.
Tartaric—White, soluble in acetic acid.
Hydrofluoric—White, insoluble in acetic acid.
Oxalic—White, insoluble in acetic acid.
Silicic—White, insoluble in acetic acid, and in all dilute acids.

Group III

Acids precipitated by Barium Acetate:

Chromic—Yellow, soluble in warm HCl.
Sulphuric—White, insoluble in HCl or HNO_3.

Group IV

Acids precipitated by Silver Acetate in the presence of acetic acid or by Silver Nitrate in the presence of nitric acid:

Hydroferrocyanic—White, soluble in KCN; insoluble in NH_4OH.
Sulphocyanic—White, curdy, soluble in NH_4OH.

Hydroferricyanic—Orange-red, soluble in NH_4OH and in KCN.
Hydrocyanic—White, soluble in KCN and in NH_4OH.
Hydroiodic—Light yellow, slightly soluble in NH_4OH, easily in KCN.
Hydrobromic—Yellowish-white, difficulty soluble in NH_4OH.
Hydrochloric—White, curdy, easily soluble in NH_4OH.
Hydrosulphuric—Black, soluble in hot dilute HNO_3.

Group V

Acids not precipitated in the preceding groups:
Arsenious gives yellow As_2S_3 with H_2S in presence of HCl or $H\text{-}C_2H_3O_2$.
Chloric gives a deep blue color with aniline sulphate and H_2SO_4.
Nitric gives the "brown ring" test.

ANALYSIS OF THE ACIDS IN SOLUTION

Use one-third of the solution for the detection of the acids of Group I, and the main portion for the detection of the acids of the other groups.

Group I.

This group includes the CO_2, SO_2, NO, S, $C_2H_3O_2$ and CN ions which are liberated by such dilute acids as HC or HNO_3.

1. CO_2. To a portion of the solution add a few drops of HCl. Effervesence and the evolution of a gas which clouds a drop of lime water shows the presence of carbonic acid.
2. SO_2. To a second portion add HCl and warm. The evolution of a gas having the odor of burning sulphur shows the presence of sulphurous acid. Thiosulphuric acid gives a white or yellow precipitate of sulphur in addition to evolving SO_2.
3. NO. Acidify a third part with acetic acid or dilute H_2SO_4 and add some $FeSO_4$. A yellow-brown or black-brown coloration shows the presence of nitrous acid.
4. S. Acidify another portion with HC and warm. If a gas is liberated which has a stale-egg odor or which blackens a strip of "lead acetate paper," H_2S is present.
5. $C_2H_3O_2$. To a fifth portion add a little alcohol, a few drops of conc. H_2SO_4, and gently warm. The formation of ethyl acetate which has a characteristic odor, shows the presence of acetic acid. Apply this test in the absence of chlorates, chromates, cyanides and iodides.
6. CN. See group IV. A. (4).

Group II.

This group contains the acids which are precipitated from neutral solutions by Calcium Acetate.

A. Boric, Phosphoric, Carbonic, Hydrocyanic and Tartaric acids which are soluble in acetic acid.

B. Hydrofluoric, Oxalic and Silicic acids which are insoluble in acetic acid.

To the major portion of the solution add conc. aqueous calcium acetate Ca $(C_2H_3O_2)_2$ in very slight excess. A white precipitate shows the presence of one or more members of this group. Filter, wash the precipitate twice with cold water and reserve the filtrate and washings for treatment under the next group.

Treat the precipitate on the filter with acetic acid passing the acid solution through the filter as long as any of the precipitate dissolves. Wash any insoluble residue twice with cold water and treat the filtrate under A and the residue under B.

A.

Divide A into four portions. Note that CN and CO_2 are both precipitated by calcium acetate, but the former is more or less soluble in water and both are decomposed by acetic acid, causing effervesence in the case of a carbonate, and giving the odor of bitter almonds with a cyanide (poison).

1. BO_2. Evaporate one portion to about one-half its volume and acidify it with normal HCl. Saturate a strip of turmeric paper with this solution and dry it at a gentle heat. If the strip assumes a pale rose-red color which in turn becomes greenish-black on adding a drop of KOH, boric acid is present.
2. PO_4. To a second portion add an excess of an ammonium molybdate solution, warm and let stand. A yellow crystalline precipitate shows the presence of phosphoric acid. Arsenic acid gives a similar precipitate.
3. $C_4H_4O_6$. Evaporate a third portion to dryness, add a drop or so of conc. H_2SO_4, and again heat. If the residue blackens and yields an odor of "burnt sugar," tartaric acid is present.

Since boric acid redissolves somewhat after being precipitated by calcium acetate, it will be necessary to test for it again under group five.

B.

1. F. Test a portion of the residue which was insoluble in acetic acid as follows: Cover a piece of window glass or a small watch glass with a thin coating of wax and when the wax is cold remove a portion of it with some sharp instrument. Mix the residue to be tested with enough conc. H_2SO_4 to make a paste and cover the exposed parts of the glass with the mixture. Let the test stand for fifteen minutes, then clean the glass and see if it has been etched where exposed. If so, hydrofluoric acid is present.
2. C_2O_4. Place another portion of the residue in a test-tube with a little MnO_2 and cover it with H_2SO_4. While boiling hold in the escaping vapor a drop of clear lime water on the end of a glass rod. If the drop becomes cloudy due to the liberation of CO_2, oxalic acid is present.

3. SiO_3. Treat a third portion with HCl and evaporate to dryness. Digest the residue with H_2O and HCl and filter. A white gritty insoluble powder indicates silicic acid as SiO_2.

Group III

This group contains Chromic and Sulphuric acids which are precipitated from the filtrate of group two by Barium Acetate.

To filtrate from Group II, add a slight excess of barium acetate, $Ba(C_2H_3O_2)_2$ and agitate. A fine white precipitate shows the presence of sulphuric acid and in that case, filter and pass to the next group. A fine yellow precipitate indicates chromic acid. If a precipitate forms, filter, wash twice and reserve the filtrate for treatment under Group IV.

1. CrO_4. Transfer the precipitate to a test-tube and warm with dilute HCl. Any chromate present will dissolve to a yellow solution, the white sulphate when present remaining undissolved. Filter, wash and confirm the presence of chromic acid by acidifying with acetic acid and adding lead acetate for yellow lead chromate.
2. SO_4. Any white residue insoluble in dilute HCl or HNO_3, confirms the presence of sulphuric acid.

Group IV

This group contains Hydroferrocyanic, Sulphocyanic, Hydroferricyanic, Hydrocyanic acids classified under portion "A," and Hydroiodic, Hydrobromic, Hydrochloric acids, classified under portion "B," which are precipitated by Silver Acetate from acetic acid solutions or by Silver Nitrate from nitric acid solutions.

Strongly acidify the filtrate from the last group with acetic acid, add silver acetate in slight excess and gently warm not boil. Filter, wash twice and reserve the filtrate for later treatment. Divide the precipitate into two portions A and B.

Portion A

Agitate A with a mixture of one part of dilute HCl and three parts of a solution of sodium chloride (1-10) which dissolves the cyanides. Filter and reject the precipitate. Divide the filtrate into three parts.

1. $Fe(CN)_6''''$. To one portion add $FeCl_3$, as long as a precipitate forms. A dark blue precipitate shows the presence of hydroferrocyanic acid. Filter.
2. CNS. If the filtrate from (1) has a blood-red color, which is destroyed by $HgCl_2$, sulphocyanic acid is present.
3. $Fe(CN)_6'''$. To a second portion add a crystal of $FeSO_4$, or a freshly prepared solution of $FeSO_4$. A dark blue precipitate shows the presence of hydroferricyanic acid. Or the filtrate from (1) may be boiled with H_2SO_4 and more $FeCl_3$ added. A dark blue precipitate shows the presence of the acid.

4. CN. To a third portion add a little picric acid, and an excess of NH_4OH and warm. If on standing a light or dark mahogany color appears, hydrocyanic acid is present.

Portion B

Place portion "B" of the precipitate in an evaporating dish with a few pieces of zinc, cover with water, add a few drops of H_2SO_4 and gently warm. When the reduction of the silver salts is complete, indicated by a black precipitate, filter and reject the precipitate. Neutralize the filtrate with Na_2CO_3, filter, reserve the filtrate and reject the precipitate.

1. I and Br. Test a portion of the filtrate as follows: Add to the test an equal volume of CS_2, and then nitro-sulphuric acid (1:1) drop by drop, vigorously agitating after the addition of each drop and noting the color of the CS_2. If the latter becomes pink or violet, HI is present; if yellow, yellow-brown or red-brown, HBr is present. The iodine is first liberated and the colored sulphide may be removed by filtering. To the filtrate add more CS_2 and repeat the operation. When all the I has been removed and liberated Br will in turn color the CS_2.
2. Acidify a second portion of the solution with HNO_3 and add $AgNO_3$ in slight excess. Filter, wash, reject the filtrate and boil the precipitate with an excess of "sesqui" ammonium carbonate. Decant the clear liquid, add a fresh portion of the carbonate and again boil. Decant as before and to the decanted liquids add enough HNO_3 to acidify. The formation of a white curdy precipitate shows the presence of hydrochloric acid. (Hager's Test.)

In the absence of HI and HBr, add to the test solution $AgNO_3$. A white curdy precipitate which is insoluble in HNO_3 and which readily dissolves in NH_4OH, shows the presence of HCl.

Note 1. When $AgNO_3$ is used as the group reagent, the procedure is unchanged except that HNO_3 must be detected in Group I. Interfering acids are nitrous, chloric, ferro and ferricyanic, sulphocyanic and the halogen acids.

Group V

This group contains Arsenious, Chloric and Nitric acids which are not precipitated in the preceding groups, being soluble.

1. ClO_3. To a minor portion of the filtrate from the last group, add a piece of zinc, a few drops of HNO_3 and gently warm. A white curdy precipitate of AgCl shows the presence of chloric acid. Or to a portion of the filtrate add a little formalin, a few drops of HNO_3 and heat, a white curdy precipitate shows the presence of $HClO_3$. In both these tests there must be present an excess of the silver salt.

Remove the silver from the main portion of the filtrate from Group IV by adding a solution of NaCl as long as a precipitate forms. Filter, wash, reject the precipitate and test the filtrate as follows:

2. AsO_3. Acidify the filtrate with acetic acid and saturate it with H_2S. If a yellow precipitate forms at once, arsenious acid is present. Filter, wash, and treat the filtrate under 3. (Omit test if arsenic was found in the analysis of the metals).
3. Concentrate the filtrate to a convenient volume, and in case chloric acid is absent, apply the "brown ring" test directly. Add an equal volume of conc. H_2SO_4 to the test, so that the two liquids will not mix, cool and pour down the side of the tube some $FeSO_4$ solution. Let the test stand for some minutes undisturbed. The formation of a brown or dark brown ring at the juncture of the acid and the test solution, shows the presence of nitric acid. Nitrous acid gives the "ring" with acetic acid in place of H_2SO_4.
4. To detect HNO_3 in the presence of $HClO_3$, acidify the concentrated filtrate, or a portion of it from 3 with acetic acid, boil for a minute with an excess of H_2SO_3. Filter if necessary, reject any precipitate and to a portion of the clear liquid add a drop or two of diphenylamine in conc. H_2SO_4. If a blue color appears at once, HNO_3 is present. This color slowly disappears.

   This test depends upon the action of the sulphurous acid in changing any chlorate present into a chloride. To determine whether all the chlorate has been changed, add to the remaining portion of the solution a drop or two of anilin, and then a few drops of conc. H_2SO_4. A blue color appears at once if any chlorate is present in which case use more of the H_2SO_3. The appearance of a blue color with this test serves to detect a chlorate in the presence of a nitrate. The anilin test gives with a nitrate a yellow-brown color.
5. BO_2. To another portion of the filtrate apply the test for boric acid given under Group II. A. (1).

AN EXPERIMENT IN THERMAL CONDUCTIVITY

PROFESSOR H. L. CURTIS, MICHIGAN AGRICULTURAL COLLEGE

The thermal conductivity K of a body is defined from the equation $H = KA \frac{\theta - \theta'}{d} T$, where H is the quantity of heat in calories which will pass in time T between the two faces of a wall of area A, of thickness d, and whose faces are at a temperature θ and θ'. It would seem that the most simple method of measuring conductivity is to proceed directly

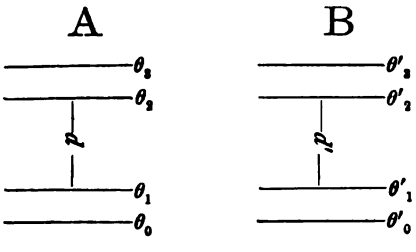
from the defination and measure the heat flowing through a given wall. I was aware that attempts had been made to keep one side of a wall at the temperature of melting ice, and the other at the temperature of boiling waer by passing steam against it, and that these attempts were unsuccessful, because a coating due to the condensation of the steam would form over the surface which would keep its temperature considerably below that of the steam. However, I reasoned that if I used hot water in the place of the steam and measured the rate of cooling of the water I would have overcome the difficulty.

Accordingly I secured two vessels, one of copper and the other of aluminum, whose conductivities I wished to determine. I filled a large pail with crushed ice and water and arranged to stir it thoroughly. I filled the aluminum vessel with a known amount of warm water and suspended it so that the bottom just touched the ice-cold water. I then read the temperature every 30 seconds while keeping the water well stirred. I then attempted to determine the conductivity as follows:

In a short interval of time, say 30 seconds, the change in temperature of the upper face will be from θ' to θ''. The quantity of heat conducted across will be M $(\theta' - \theta'')$ where M is the mass of the water. The temperature of the upper face may be taken as the mean of the two. Substituting in the formula for conductivity M $(\theta' - \theta'') = K A \frac{\theta' + \theta''}{2d} T$, since $\theta_0 = O°C$. A somewhat simpler formula can be obtained by integrating the differential equation which expresses the conductivity, but that solution would be out of place here.

The results obtained by this method were very much too small. As the only error of great magnitude must be in the temperatures of the two faces, I determined to examine into this. For that purpose I had made two vessels identical, except that the bottom of one was of a different thickness from the other. My experiments had caused me to conclude that there is a surface film of water through which the heat must be conducted, the film not being disturbed by the stirring. If this is the case, the following considerations will hold:

Let A and B be sections through the two plates of which the bottoms of the vessels are made. In these d and d′ represent the thickness of the two metals, above and below which are the films of water. Let the temperatures of the different surfaces be as represented.



When the temperature gradient in the metals of A is the same as that in B., i. e., when $\frac{\theta_2 - \theta_1}{d} = \frac{\theta_2' - \theta_1'}{d'}$ the same quantity of heat will flow in a unit of time through unit cross-section of the two plates provided the thickness of the films on the two plates is the same, and they have the same conductivity. We will then measure the flow of heat

through the two plates and determine temperatures above the upper films when this flow is the same in A and B. Then since the temperature gradient over the upper films will be the same, the temperature gradient in the metal is $\frac{\theta_2'-\theta_2}{d''-d'}$. This can be substituted for $\frac{\theta-\theta'}{d'}$ in the formula for conductivity, and the remainder of the solution will be as indicated before.

It should be noticed that anything that will effect the nature of the film will materially effect the result. I have found that when a second pail of ice water is used, all other things remaining the same, the rate at which the cooling proceeds is quite noticeably effected. I have taken several readings upon brass, and have the following results which are the most consistent I have been able to obtain:

Accepted values .....0.20—0.25
Values obtained 1st 0.14
2nd 0.11

From lack of time I have not been able to give this a fair test. I wish to try the experiment using distilled water and carefully cleaned surfaces.

I have assumed that the thickness of the film and its conductivity do not change with temperature. This needs careful examination.

SOME USES OF THE ALTERNATING CURRENT IN HIGH SCHOOL WORK

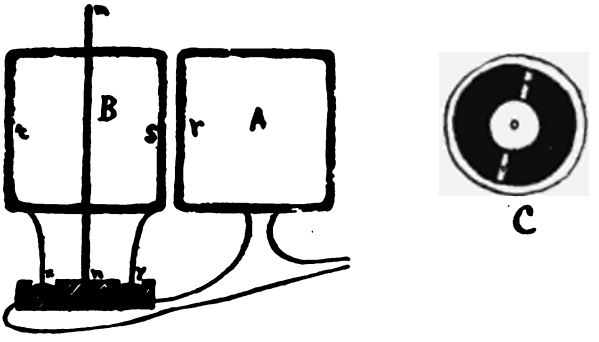
L. M. PARROTT, SAGINAW

I believe the alternating current may be made of almost universal application in outlining fundamental principles, and as an auxiliary apparatus it is almost indispensable.

In my own work the subject of electricity is opened by attempting to get before the pupil a clear conception of the terms used, and the definite meaning of each of these terms. This naturally leads into the subject of the fundamental properties of the current, and this point, to my mind, is the basic principle upon which the entire superstructure is founded. A clear conception of these fundamental properties is therefore absolutely essential, and must be made clear and definite by actual existing evidence.

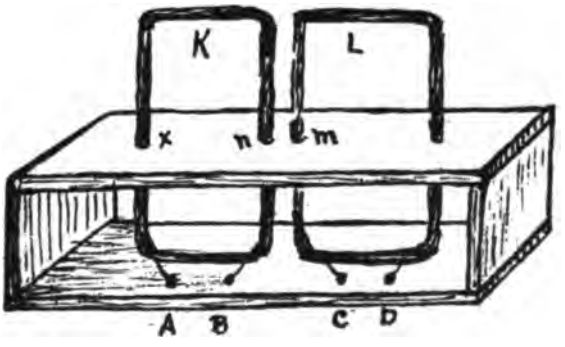
I believe we will all agree that the greatest and most important, if not *the* fundamental property is manifested by what is called, for lack of a better term, the field of force; and until the actual relation between the current and its accompanying lines of force is made unquestionably evident to the pupil's mind, all that the subject can

give him will be but a hazy and imperfect idea. Experiment only can settle the question, and for this purpose a small current is not satisfactory. We are reduced, therefore, in the great majority of schools at least, to the problem of either using a large number of cells, to be made by the teacher at this time, or else making use of the city's incandescent plant, which supplies an alternating current. The latter



is cheap, always ready, easily manipulated, and will show many of the essential relations as completely as a direct current.

To illustrate: If we connect the terminals of the alternating current, through a suitable rheostat, to the posts A and B (Fig. 1) respectively, so that it serges back and forth through the coil K, and sprinkle iron filings around the point x, the circular lines of force will be evi-



dent, thus showing the existence of a field of stress of some nature encircling the current carrying wire. These lines of stress, however, may be more than mere circles of force, and are possibly endowed with some kind of a direction property as well, or possess what might be termed a head and tail with the heads all turned one way with reference to the direction of the current. This question may also be clearly demonstrated by means of our alternating current.

Assume, if you will, that this stress about the wire, or so-called field of force, *is* endowed with a direction property; then, if we assume a particular direction in which the lines are all headed with reference to the direction of the current, and now arrange two parallel wires with current flowing in opposite directions, by connecting the terminals at *A* and *D*, and an extra wire from *B* to *C*, so that the current flows through both coils represented in Fig. 1, the combined field would necessarily be a thick and highly strained field between the two wires. Now, still supposing this same direction property, if we exchange the terminals *A* and *B*, thus reversing the current in one of the coils, we will have it passing through the two central wires, parallel, and in the same direction. Under this condition a line of force circling around the wire *m* would, when attempting to exert its force, or as some would say, when attempting to pass, between the wires, come under the influence of the current in wire *n*, and thus be prevented from exerting itself in the space between the wires, and, affected by this influence, must continue on around the wire *n*, and so encircle both wires, presenting one entire circular or oval field.

Connecting up respectively in the two ways indicated, we see the fields are so arranged. This effect must therefore be due to the cause indicated, and we are inevitably compelled to accept the fact that all lines of force do possess a direction property of some nature. That is, when the current goes one direction, the lines of force also have a direction property, dependent on the current direction. Assuming a head and tail for each line, we mean the heads are all turned one direction around the wire. Which direction we call head, or which tail depends only on convention, and convention has established that the arrow head in the figure is to be called head, or, as ofttimes falsely stated, the line passes around the wire in the direction indicated, the dot meaning current coming up out of the paper.

Some additional facts may be deduced from the two fields described.

Turning our attention to these fields and remembering that these lines are a stress or strain around the current carrying wire, and should therefore act like stretched elastic bands, we note certain actions likely to result. In the first mentioned field these lines are crowded and need more room. Therefore, by their very nature, they should press these wires apart. On the other hand, the situation as exemplified in the second field should be such as to cause the wires to be drawn together.

These facts may be illustrated by means of two coils set up as indicated, the alternating current being fully as effective in proving these well known laws as a direct one.

This simple apparatus may be briefly described as follows: *A* and *B* are two coils connected in series, *A* stationary, and *B* supported by a central axis mn upon which it may freely turn, its ends dipping into the respective grooves which are filled with mercury. These grooves are illustrated

by view *C*, and are so arranged that when the coils are parallel with each other, current is flowing in opposite directions at s and r respectively. *B* is rotated because of the repulsion set up by the crowded condition of the lines of force, and *t* is attracted. t would thus stop near r, but just as it reaches that point, the ends *x* and *y* pass over the bridges *u* and *v* (built of paraffine), reversing the current in the coil *B*, thus insuring continual rotation. The terminals *x* and *y* are double ones, each being made up of two terminals in parallel spread apart slightly more than the width of the bridges *u* and *v*. This will shunt the coil *B* for an instant each half revolution doing no harm thereby, and will prevent the self-induction spark caused by breaking the circuit from fusing the terminals. This experiment not only illustrates these fundamental laws, but may, at the same time, give the pupil a starting point from which to work out the motor and its commutator.

One other fact may be shown from the conditions above. When the current passes the same direction in two parallel wires, we have seen that the field of force encircles both the wires, and that iron seems to be an excellent conductor or retainer of this stress. If, therefore, we wind a wire in the form of a solenoid we have an extended condition of the same idea, the combined result of which is that we have lines of force running through the whole coil and returning round the outside. If now a piece of iron were placed near the end of such a group of parallel lines of force, these lines, like stretched elastic bands, in attempting to manifest their own nature, would pull the iron closer, and if not too large, within the coil. This illustrates so-called magnetic attraction, which is nothing more nor less than the lines of force attempting to manifest their own nature. This fact may be illustrated by hanging such a coil by one end, and then holding a large nail near the lower end. It will be lifted out of the hand. A perceptible heating may be felt manifested in the nail which is practically absent when the same experiment is tried with a direct current. This will certainly aid in giving some idea of what takes place within the nail at each alternation of the current, which, as we have previously seen, is accompanied by a reversal in the direction of the lines of force sent through the coil and hence through the nail. The vibrations caused by these reversals will also be plainly perceptible to the hand holding it. Magnetism, to my mind, may be made clearer and more real if it were made to follow and not to precede, as in most texts, the experimental evidence of this fundamental property of a current: its field of force.

By some such simple experiments as these, all with "home made" apparatus, I believe nearly all the fundamental properties of the electric current may be easily demonstrated with the city's incandescent or alternating system. It is cheap and very convenient, and a current of some kind is a practical necessity in every school in order that our

young people may obtain a clear idea of the subject. As an auxiliary aid in the lecture room, I find it almost indispensable.

Take, for example, one illustration, the arc light. I confess I cannot well get along without it. With it we may accurately illustrate the law of inverse squares, focus and conjugate foci of concave mirrors, laws of reflection of mirrors, not to mention the value of the stereopticon. How to use it to adequately show the laws of reflection of mirrors may need a little further explanation.

We have a tank about five feet long and four broad with a glass bottom. I support this at its ends and place the light and a mirror (either a large concave or plane) beneath in such a way as to reflect the light upward. Placing water in the tank to the depth of about one-half inch, and a piece of wood, held down with a weight, cut, say, in the form of a concave mirror; by touching the water with the end of a ruler at some point as, x, representing the position of the object, the waves will proceed to the mirror and be reflected, coming to a point which represents the position of the image. To send parallel rays to the mirror it is only necessary to touch the whole length of the ruler simultaneously. With the electric light below the tank the whole picture is thus magnified and projected upon the ceiling and the whole problem made evident.

ALTERNATING CURRENT APPARATUS AND EXPERIMENTS

A. O. WILKINSON, WESTERN HIGH SCHOOL, DETROIT

The purpose of this paper is merely to call attention to the apparatus that I have assembled for experiments with the alternating current, illustrating some of its properties and uses. I was fortunate in obtaining two discarded regulating coils from the Western Alternating Current Arc Lamp, old form. The four coils of one of these (a. Fig. 1) I have so connected with binding posts, plugs, and switches that it may be used as a step down transformer, as a step up transformer, or as a transformer without change of voltage. It may also be used as an inductive resistance. Figure 2 is a view of the top of this showing coils, plugs, switches, and connections. The alternating current circuit, 110 volts, is connected to the primary posts, a one hundred ten volt lamp is connected to the secondary posts, both switches are on contact No. 1, coils, 2, 3, and 4 are connected with plugs. This is then a step down transformer and the lamp is very dim. By placing switches A and B on No. 2; and connecting coils 1 and 2; also 3 and 4 by plugs, the lamp gives its usual candle power. If switches A and B are placed on No. 3 and coils 1, 2, and 3 are connected, it becomes a step up transformer and the lamp lights with dazzling brilliancy.

This may be used as an inductive resistance by connecting the alternating circuit to primary post No. 1 and secondary No. 1 and connecting by plugs coils 2, 3 and 4 with switches A and B both on 1. By changing switch A to 2, one coil is cut out, changing to 3, two coils are out, changing to 4, three coils are out. All four coils may be cut out by placing both switches on contact No. 1 and connecting coils 1 and 2.

The four parts of the other coil (b. Fig. 1) are so connected as to make it the stator of a small induction motor. The two opposite coils are so connected that they will produce like poles in the same

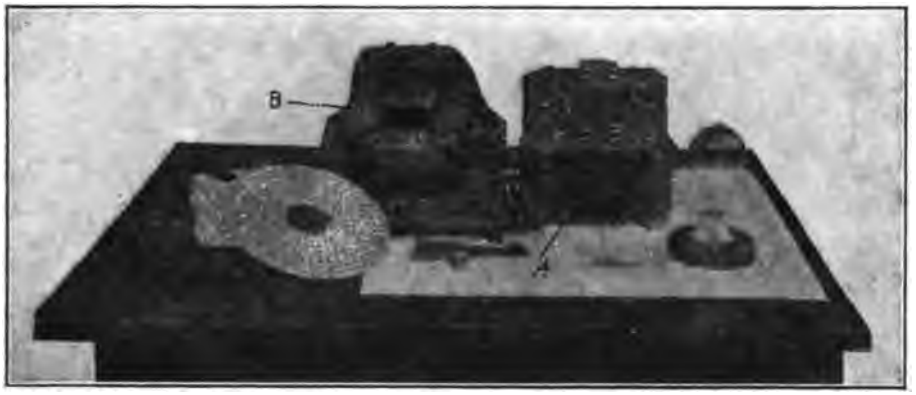


Fig. 1

direction at the same time; that is, they oppose each other. These are connected to the alternating circuit through a non-inductive resistance. The other two coils are joined in like manner and connected with the same circuit through the inductive resistance above described. These connections are shown in Fig. 3. This inductive resistance will produce such a lag of the current in that circuit as will make the magnetic field a rotating one. This rotating field may be shown by placing within the coil, the block with a small iron bar supported on top, shown in Fig. 1. The bar is pulled around by the rapidly rotating field. When its rate becomes the same as the field, either circuit may be disconnected and the bar will continue to rotate in synchronism with the field.

An alumnium siren supported on a pivot just above the coil may be made to rotate at any desired speed by varying the current; it will rotate much more rapidly if a piece of sheet iron is held just above the siren.

By removing the block, the small squirrel cage armature shown in Fig. 1 may be placed within the coil. It will rotate rapidly, illustrating the principle of the induction motor. If a four-inch watch glass be

placed on top of the coil and any kind of metal ball be placed on this glass it will rotate.

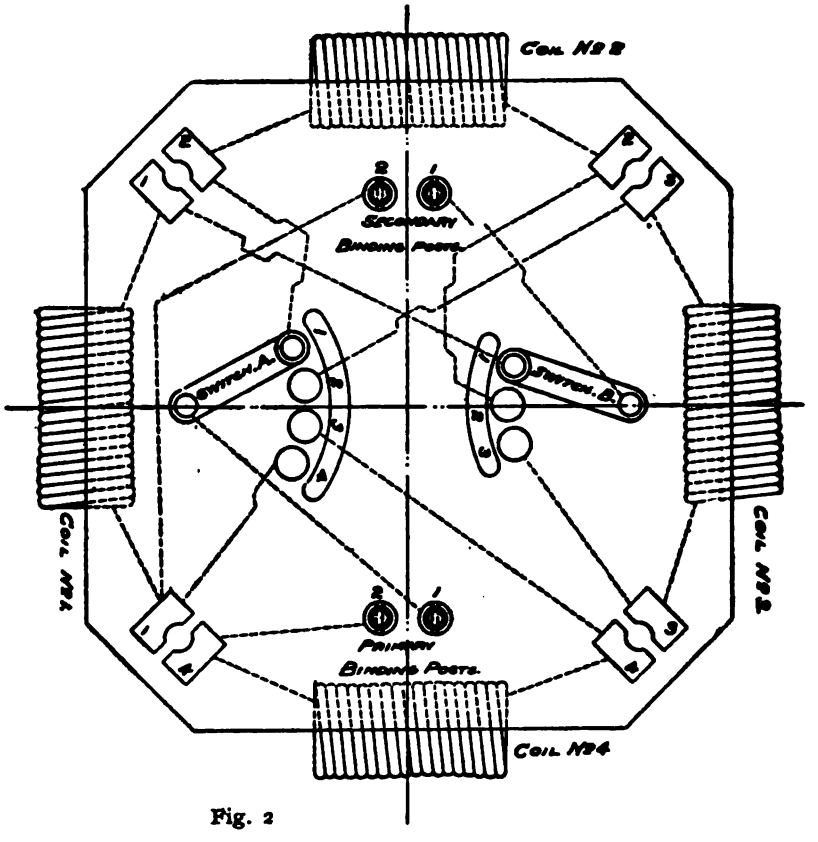


Fig. 2

By filling the shell of a hen's egg with iron filings and placing it on this glass, an amusing experiment may be given. At first it begins

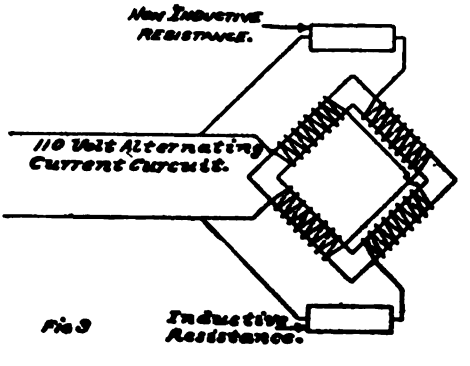


Fig 3

to rotate on its side or on its shorter axis, but after attaining a certain

velocity it will stand up and rotate on the end. It is perhaps unnecessary to say that the same experiments may be performed by using in place of the inductive resistance the same apparatus as a step down transformer.

NOTE.—The Scientific American of May 6, 1906, has a valuable article on this subject.

THE ENTRANCE REQUIREMENT IN PHYSICS AND ITS RELATION TO THE PHYSICS OF THE COLLEGE COURSE

PROFESSOR N. F. SMITH, OLIVET COLLEGE

A conference such as this, composed of representatives from the university, the colleges and the secondary schools, seems to be a peculiarly appropriate place to discuss a question directly affecting our mutual relations. I know that the subject of the college entrance requirement in physics is an old one, but educational conditions in schools and colleges are changing so rapidly as to warrant the reconsideration of some aspects of this theme. My subject seems naturally divided into three parts, which I wish to consider in order.

1. Should physics be a required subject for admission?

I think the time has come when all of us are ready to admit that those subjects form the best basis for entrance to college which give the best preparation to the students whose education is finished with the high school course. My question might therefore be put in the form: "Should physics be a required subject in the high school course?" In this day when the elective system has been allowed to run riot through our courses of study there is a tendency to make practically all subjects optional, both in school and college. Whatever may be said in favor of such a system in the college or university,—and I believe myself that it is very little,—these arguments certainly do not apply to the high school where the pupils are far too immature to make a choice of subjects on any rational basis. Some subjects then should be prescribed as required of all students in the high school course. Among these should be a certain amount of science work, and among the sciences, it seems to me there are strong reasons for selecting physics.

These reasons are chiefly as follows: (a) Physics is a dicsiplinary study comparable to mathematics or Latin, and possesses this characteristic perhaps to a greater degree than any of the other sciences of the high school course. (b) The principles of physics are fundamental, underlying the other sciences and forming a proper basis for their study. (c) A knowledge of the elements of physics is essential to any

intelligent understanding of the great forces in constant use in every-day life.

From the college point of view, then, it would seem that physics should be a required subject for admission quite as much for the sake of those students who do not go to college as for those who do, since making physics a requirement for college entrance will tend to keep it a requirement in the high school course. In opposition to this view, objections based on local conditions of expediency are sometimes urged. A high school is pointed out which is equipped, either in teaching force or apparatus or both, to do good work in chemistry, but is poorly equipped for work in physics. We are asked whether it is not better for that school to continue its course in chemistry and not undertake the work in physics. My answer is yes, if it cannot do both in a satisfactory manner. But that is not a reason why the general principle should be changed or why the college should change its entrance requirement. A somewhat similar objection is based on the expense involved in providing equipment for proper instruction in physics, which perhaps exceeds that required for the other sciences. I shall refer to this more fully under the next division of my subject, but I wish to say here that the few hundred dollars' expense initially involved is insignificant when any educational principle is at stake, and, secondly, that the great mistake of the small high schools seems to me to be the attempt to include in their curriculum all of the sciences instead of concentrating their energies and their resources upon one or two. Let the small high school with only three or four teachers gave up the attempt to teach zoology, botany, physiology, physics, chemistry, and what not, and perfect a thorough course in one or two of these subjects and the expense will be no more and the educational results far better.

My last reason for urging physics as an entrance requirement is one based on the desirability for uniformity in this matter. Physics is of course *accepted* as an entrance subject by all the colleges. There seems to be a growing tendency to make it a required subject. Especially is this true in our own state where it is required by the University of Michigan, Olivet, Hillsdale, Kalamazoo, Adrian, and Hope. It seems to be optional at Alma and Albion,—the latter specifying in the science requirement, "physics preferred."*

It may well be asked why, if physics is already required by practically all the Michigan colleges, it is necessary to discuss this phase of the subject. I reply, to emphasize the importance to the smaller high schools concentrating their attention upon this one science, not merely because it is a required subject for admission to college, but because it is best for the educational development of their pupils that this one

*Physics is now required for admission to Albion College.

science should be taught well rather than that several sciences should be taught indifferently.

2. If physics is presented as an entrance subject, what should constitute a unit course? Here again I wish to emphasize the fact that the sort of a course which seems desirable as a preparation for college differs in no way from the course which is best for the students who do not go to college. It is true, however, that the requirements of the colleges and particularly of the State University, have had and will always have a tremendous influence in determining the character of the courses offered in the high schools. No fountain rises higher than its source, and the source of the teaching in the high schools is the University and the colleges. The standard of this teaching is largely determined by the minimum entrance requirements of these institutions. If the Michigan colleges have taken the lead in placing physics among the required subjects for admission, they are lamentably behind most other institutions in the character of the course which they require for college entrance. I do not, in this place, need to argue the importance of individual laboratory work on the part of the student as a part of the preparatory course in physics. Most of us would agree that this work should be chiefly quantitative in its nature and that a proper record of the experiments should be kept by the student. Nothing less han this is accepted as meeting the admission requirements by any college or university of the first rank, so far as I know, outside the state of Michigan. Nothing less than this is worthy of the high schools of this state where an attempt is made to present the subject. And yet in studying the catalogues and inquiring into the practice of the colleges of Michigan, I find great uncertainty or great deficiency on this point. This is due in large measure to the position taken by the University of Michigan, the natural educational leader in this state.

I am pleased to note in the announcements of the last two years a distinct advance over the statement in the earlier catalogues of the University. The last announcement in defining the physics requirement says: "The course should include one period of laboratory work per week, throughout the year." This is better than the previous statement: "Laboratory work is earnestly advised but not required," but even the last statement is far too vague. Does the University *require* such work for admission? What does it regard as a satisfactory laboratory course? What means are taken to ascetrain the character of the student's laboratory work? These are questions which should be more explicitly defined.

Albion College admits without examination students from all schools approved by the University of Michigan, thus indorsing their standard. Kalamazoo defines her entrance requirements somewhat vaguely. An idea of what is considered acceptable may be gained by a reference to her own preparatory course. "Physics; Fourth year; fall

and winter terms; many experiments in which the pupils frequently assist are performed before the class." Hope College accepts the standard of the University of Michigan. Adrian gives no specifications. Alma specifies "the equivalent of Carhart & Chutes' text together with an approved laboratory course of not less than forty experiments actually performed at the school by the candidate." Hillsdale's catalogue gives no information on this point, but I learn by direct inquiry that the requirement includes an approved course of *quantitative* experiments and that the student's original note-book must be presented for inspection. The Olivet catalogue specifies, "At least thirty *quantitative* experiments performed by the student, and the note-book presented to the Admission Committee." We see therefore that probably four and possibly five of Michigan's higher institutions do not regard individual quantitative laboratory work as an essential part of the high school physics course; the University is not explicit in its statement although its practice in the past has been not to require such preparation of its students; while three of the colleges maintain such a laboratory requirement.

Turning our attention now to other states, we may refer to the physics requirement as defined by the College Entrance Examination Board, which has been adopted by practically all of the eastern institutions. This requirement is based on the report of the Committee on Physics of the Science Department of the National Educational Association. The candidate's preparation must include individual laboratory work comprising at least thirty-five exercises selected from a list of sixty-one, all but four or five of which are quantitative. The laboratory note-book must be presented for inspection. The definition of the requirement by the North Central Association of Colleges and Secondary Schools,—to which the University of Michigan, Albion and Olivet belong—is identical with that just read. Referring now to a large list of individual catalogues of colleges and universities I have found not a single one outside our own state which contains an intimation that laboratory work is not required. In many catalogues the requirements are not clearly defined but referring to catalogues of the University of Chicago, Northwestern, Illinois, Wisconsin, Kansas, Leland Stanford, Washington, Missouri, Western Reserve, Cornell and Vermont, and such colleges as Bowdoin, Amherst, Beloit, Knox, Washburn, Iowa and many others, the requirement for a definite amount of laboratory work is distinctly stated. Why should the schools, the colleges and the University of Michigan be behind other states in this respect? The University defended its position in the past by saying that the high schools were not yet prepared to do satisfactory laboratory work in physics. I fear that in many cases this is true today even in schools upon the accredited list of the University, but is not the reason largely due to the lack of incentive which the University and the colleges have offered them to do this work?

The objection is often raised that the expenses involved in the equipment of a physical laboratory renders it impossible in the small high school. I am sure that this feeling arises from an ignorance of the facts. I have within the last two years advised with the school boards and superintendents in several small towns concerning the equipment of their schools for laboratory work in physics. I am satisfied with an initial expense of one hundred and fifty dollars properly expended will enable any school in a town of not over fifteen hundred to commence a satisfactory laboratory course, and the additional expenditure of forty or fifty dollars per year for a period of a few years will soon secure an excellent equipment for high school work. And why did these schools ask this advice and make this start? Primarily, of course, because they wished to improve the grade of their work, but in each case the *immediate* cause was a desire to be placed on the accredited list of Olivet College. If one institution can effect this result in a few schools how much would be the improvement of our physics instruction if all the institutions of the state should act together!

It would seem, then, that in accordance with the requirements of the leading colleges and universities of the country, east and west, and in accordance with the methods of presenting the subject generally recognized as best, the time has come when the higher institutions of Michigan should insist on a definite amount of *individual, quantitative* laboratory work as a part of the entrance requirement in physics. To insure the carrying out of this requirement, it seems necessary, for the present at least, to insist that each candidate for admission shall present the record of his laboratory work, duly certified, to the proper college officer. That this would do more than any other single thing to improve the character of the physics teaching in the smaller high schools I think there is no doubt.

3. But little space is left for me to discuss the third division of my subject, viz: the bearing of the physics entrance requirement on the college course in general physics. It goes without saying that students in the same class should have approximately the same preparation for the course. The college course in general physics should be a second year course in the subject in which it may be assumed It may be necessary ta review these briefly but the course should be that the student is familiar with the elementary physical phenomena. devoted chiefly to a discussion of those portions of the subject which are beyond the scope of the high school course, e. g., simple harmonic motion, moment of inertia, the simple and compound pendulum, the kinetic theory of gases, etc. It seems to me quite as important that laboratory work should accompany this study as that it should form a part of the work of the earlier course, but the experiments should be of a distinctly higher grade. It does not seem worth while that the student should repeat experiments which he has carefully performed

before, the only variation being perhaps the use of somewhat better apparatus and the addition of a few corrections as, for example, most of the determinations of density. The experiments should rather be carefully chosen to illustrate the new principles which are being discussed in the lecture room. And yet no satisfactory set of experiments can be made up for the college course unless it can be assumed that the students in it have already performed a set of quantitative experiments illustrative of the more elementary principles of physics. There is not time in the college course to teach these principles, and nothing fixes a principle in the student's mind so well as making it the basis of a quantitative experiment. It is not fair to a large number of students who have adequate preparation in physics to adapt the college course to the needs of those who have not.

Let me repeat in conclusion the three points which I have tried to make: 1st, that physics should be required of all students for admission to college; 2d, that individual quantitative laboratory work should form a part of the work required; 3d, that the college course in general physics should presuppose such a course and should be adapted both in the work of the laboratory and the lecture room to the needs of students who have had such preparation.

THE ENTRANCE REQUIREMENT IN PHYSICS AND ITS RELATION TO THE PHYSICS OF THE COLLEGE COURSE

PROFESSOR C. W. GREENE, ALBION COLLEGE

In the consideration of the subject of "Entrance Requirements" there are, unfortunately, usually two distinct viewpoints. From the first, we ask what requirements shall be made in order to insure the best possible preparation of the high school student who expects to attend college, for the successful pursuance of college work. From the second, we inquire as to what shall be the content of that high school course which shall most enrich the life of the ordinary student, who will never enjoy the privileges derived from a college education. Although possessing in common with the other members of this conference a strong desire to make our first college course in physics effective in the highest degree, I yet maintain that we should consider the subject in hand mainly from the second viewpoint.

However, whether we occupy one viewpoint or the other, it is clearly evident that strong and yet reasonable college entrance requirements have exerted, and will continue to exert, a strong influence on the development of the high school courses of study in Michigan. Such requirements, therefore, benefit alike students who enter college and

those who do not. Whether we be physicists, chemists, biologists, mathematicians, or followers of some other line of scientific work, we shall, I believe, all agree that physics should be a required subject for entrance to college. I shall mention but three of the reasons that might be advanced for making this requirement: (1) At least a high school course in physics is a fundamental prerequisite to the pursuance of any college course in science. (2) In the field of physics the high school student finds an opportunity for interesting and practical applications of his mathematics. (3) Because of the nature of the subject matter, the course in physics develops in the student a keener appreciation for and ability to interpret, many of the ordinary phenomena practically related to every-day life. In cooking, in heating, in lighting, in the working of the machinery of the manufacturing plant, in transportation,—in short, in the controllable and uncontrollable manifestations of nature, the student sees the workings of the laws of physics. This third reason alone is sufficient, I believe, to justify the colleges in making physics an entrance requirement; for the colleges would thereby exert a strong influence toward strengthening the high school courses in physics.

In the determination of what should constitute a unit course in physics, there are two elements that should be taken into consideration, —(1) the time element; (2) the subject matter of the course. As regards the former, it should be required that not less than the equivalent of four recitation periods, of forty-five minutes each, per week, throughout the year, be given to the subject. As regards the subject matter and requirements made of the students, it is my opinion that the high school course in physics should not be an abbreviated course in college physics, nor of its intensive character; but that it should be of a more popular character, a course that along with the intellectual development which it gives the pupil, will also give him a large fund of information regarding physical laws and phenomena.

I would not have you infer that I favor the under emphasis, in any degree whatever, of the real essentials of the course. Unfortunately, it is too often taken for granted that high school students know many facts, perfectly evident to the specialist, which facts the students have never had the opportunity or occasion to learn; it is too often assumed that pupils have powers of analysis and reasoning that teachers have no right to expect of pupils of high school age. The pedagogy of physics would, in my judgment, be a profitable subject for consideration by some one at some future meeting of this conference.

To be specific, what should constitute a unit course in physics for the average high school, insofar as the text-book work is concerned, may be illustrated by the content of such a text as Carhart and Chute's High School Physics under the following conditions: (1) About one-third of the most difficult problems should be replaced by questions

relating to common phenomena, the answers to which illustrate physical principles studied. For instance, would it not be wise to introduce more such questions as, "Why does a person lean forward in climbing a hill?" "How is inertia illustrated in the beating of a carpet, or in the stamping of the snow from the feet?" 'Why does a partially deaf person place his open hand back of his ear when listening to a speaker?"

(2) It is highly desirable that a separate grouping be made of problems that are to be solved by the graphical method, if such problems are to be given at all; and that specific directions as to methods of construction and instruments to be used, precede the first list of problems to be solved graphically.

(3) The insertion of a tabulation of fundamentals at the close of each chapter would materially assist the student in the average high school to organize his knowledge.

(4) For the benefit of the teachers in our medium grade high schools, about forty to fifty of the least essential topics should be designated as optional.

I trust it is evident from what I have said that the suggestions made are meant to be for the benefit of the medium grade high schools, and are not meant to apply to high schools of the class of Ann Arbor, Lansing, Detroit, and similar schools; for the work of teaching physics in these latter schools is in the hands of those who are abundantly able to cope with the problems that arise, without any suggestions on our part. Again, I do not wish to be regarded as an exponent of adverse criticism of the text-book mentioned. That particular text was cited because its content is familiar to all members of this conference, and because it probably meets the needs of the average high school as fully as does any other text on the market.

With regard to the laboratory work, it is desirable that one double period per week be devoted to qualitative and quantitative experiments performed by the students *under the supervision of the instructor.* However, I do not deem it to be practicable at the present time for the colleges to fix a definite amount of quantitative work as a part of the required unit for entrance to college. It is my belief that a little missionary work done by this conference would be productive of greater benefit to the teaching of physics in the high schools of our state. A suggestive list of perhaps eighty to one hundred experiments suitably correlated with the work of the text-book, accompanied by a brief statement of the apparatus necessary for performing each and cost of same, would be a boon to many a teacher of high school physics. In my opinion, it would be very desirable for a committee of this conference to be appointed to investigate to what extent quantitative laboratory work is being done in the high schools of our state, and in what ways this conference can assist in the further strengthening of the

instruction in high school physics; and for such committee to report the results of its work at our next conference.

Although I do not deem it expedient for the colleges to make quantitative laboratory work a part of the entrance requirement at present, I do favor our giving strong encouragement to the development of systematic laboratory work. To that end, a certain number of hours advanced credit should be given to students who have completed a strong laboratory course, under the following conditions: (1) The student should present a systematically kept laboratory book. (2) He should either pass a satisfactory examination upon the content of his note book, or, if he enrolls for a college laboratory course, he should give evidence by the character of his work that he understands the significance of the work for which he asks credit. (3) The number of hours of advanced credit given should vary somewhat according to the character and extent of laboratory work done.

The first college course in laboratory work should be sufficiently flexible so that it will accommodate both those who have had a good course in the high school and those who have not. It is my belief, also, that the first college course in physics should consist of correlated text-book and laboratory work. Closer correlation renders the subject matter of the course more readily understood; it gives the student more of a realizing sense of the significance of the work; and, at the same time, it gives the student a keener interest in and a greater love for, the subject of physics.

BOYLE'S LAW APPARATUS

MR. C. D. CARPENTER, MICHIGAN STATE NORMAL COLLEGE

A very good instrument to use in demonstrating Boyle's law is shown in the accompanying cut. It is similar to the J-shaped one in common use, differing in that the short arm is about 90 cm. long with a glass stop cock at the end, while the long arm is about 150 cm. long, opening at the upper end with a small funnel into which the mercury may be poured, and at the lower end with a stop cock by means of which mercury may be drawn off. Thus by the use of the stop cocks the heights of the mercury columns can be adjusted, and the volume of the gas and the amount of pressure varied at pleasure.

In the use of the instrument, the sum of the barometer reading and the height of the mercury in the long arm minus the height of the mercury in the short arm is always used as the pressure. The length of the short arm (properly calibrater) minus the height of the mercury in it may always be regarded as the volume of the gas. The extra length of the short arm

enables one to use the instrument as a barometer. By starting with about 30 or 40 cm. of gas the pressure may be varied from one-half an atmosphere to nearly two.

In the performance of this experiment the same precautions must be taken as are necessary in the use of other instruments. The mercury must be perfectly pure and dry, the instrument dry and clean, and the gas used must also be dry in order to obtain the best results. A small rubber band looped around the glass tube and over the stop-cock will prohibit accidents of spilling the mercury.

The instrument can be made by most teachers of physics and chemistry and at a very little expense.

AN EXPERIMENT IN UNDER COOLING

C. F. ADAMS, CENTRAL HIGH SCHOOL, DETROIT

The cooling of a liquid below its freezing point without solidification is very easily and beautifully shown by the use of glacial acetic acid. The absolute acid is said to freeze at 17 deg. C., but that containing 99 or 99.5 per cent acid freezes at about 13 deg. C. Fill a large test tube, or, better, a large ignition tube, about half full with the acid and close this tube with a rubber stopper having a thermometer extending through it into the acid. Place this tube in a mixture of ice and water. In this way the acid may be cooled to nearly 0 deg. C. without freezing; but a gentle tap on the inside of the tube with the thermometer starts the freezing and the whole becomes solid with a rapid rise of temperature tothe freezing point. The experiment may be quickly repeated after melting the acid by setting the tube in a beaker of tepid water.

THE NERNST LAMP IN THE LABORATORY AND SIMPLE EXPERIMENTS ON RADIO-ACTIVITY

F. R. GORTON, MICHIGAN STATE NORMAL COLLEGE, YPSILANTI, MICH.

The Nernst lamp consists essentially of a specially prepared filament A, Fig. 1, called the glower, and a series resistance B, called the ballast. The glower possesses the property of conducting electricity only when hot. Joining a glower and a corresponding ballast across the electric lighting mains and heating the filament in a flame brings it into a conducting condition after which the current quickly carries it to a temperature at which it gives off an intense light. The ballast

consists of an iron wire of such a length and size as to offer sufficient resistance while conducting the necessary current. Obviously the glowers and the ballasts must be adapted to the voltage on which they are to operate. These parts of the lamp already described can be had neatly mounted in lamp bodies in which the initial heating of the glower is done automatically by the current. While the complete lamps are excellent for commercial lighting purposes, a more convenient mounting is desirable for use in the laboratory. One form that has been found useful for many purposes is shown in cross-section in Fig. 2. The parts are mounted on part of a porcelain ceiling rosette used

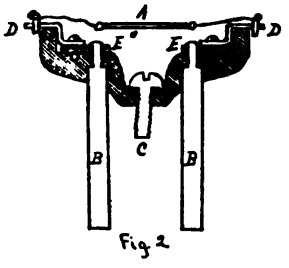


Fig. 2

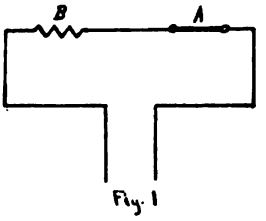


Fig. 1

in electric wiring. BB are two brass posts passing through the screw holes in the porcelain and attaching to the small brass plates EE. The joints cannot be soldered on account of the heat produced while the lamp is in operation. To the plates EE are attached the metal extensions DD. These are drilled near the outer ends to receive the small

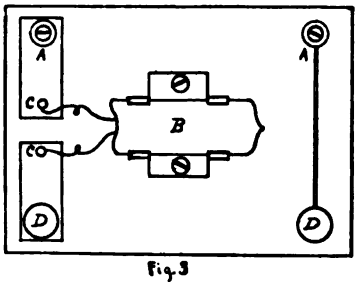


Fig. 3

aluminum pins with which each glower is provided. The large screw C serves to connect the lamp to the kind of holder or stand desired. The metal parts can be protected from the intense heat of the glower by filling the holder with plaster of Paris. The electrical connections are made by attaching flexible lamp cord to the ends of the posts BB. These contacts may be soldered. It is advisable to fit pieces of glass tubing over the posts before attaching the wires to prevent short-circuiting. The ballast may be placed anywhere in the circuit. A convenient mount is shown in Fig. 3.

The lamp as described serves admirably as a luminant for projection purposes for pictures five or six feet in diameter. Smaller pictures in a partially darkened room can be distinctly seen by a class. Two 110-volt glowers serve for projection in a room seating three or four hundred.

Another application can be made in rendering galvanometer deflections visible to a class. Place the lamp about 75 cms. in front of a mirror galvanometer and a convex lens whose principal focal length is 50 cms. about 65 cms. from the lamp and between the two. A brilliant image of the glower will be reflected upon a screen or scale placed behind the lamp at a distance of about two meters. Of course, other lenses than that mentioned may be used and the correct position of all the parts found by trial. The image is bright enough to be observed without darkening the room.

A brilliant point source for experimental purposes can be produced by placing a slit near, and at right angles to, the glower. For work in optics not requiring a very narrow slit, the glower itself serves very well.

Other uses will suggest themselves to teachers of physics as they come to use this luminant. The glowers and ballasts are made both for direct and alternating currents. They can be procured from the Nernst Lamp Co., of Pittsburg, Pa., or Chicago. The nature of the current and the voltage must be stated in ordering the parts.

Two effects of radio-active substances are easily made use of in the laboratory; viz., the photographic action and the electrical effect due to the radiations emitted by such bodies. Probably the most accassible substance possessing the property in any marked degree is to be found in the Welsbach gas mantle. If such a mantle is laid flat against the film of an ordinary sensitive plate and left in the dark for a week or more before being removed, the process of development will bring out a distinct image of the mantle. The experiment can be made by using the mineral Pitchblende, or Uraninite, which is usually found in mineralogical collections and is kept in stock by dealers in such materials. Good results can be obtained by breaking the rock in small pieces and strewing it around upon the plate. If a coin, for example, is first placed on the plate, a clear spot will result on developing due to the shielding action of the metal. The activity of the mantle is due to the presence of Thorium, while that of the pitchblende arises from the Uranium contained in it. A part of the activity of the latter may be due, however, to the presence of a trace of Radium which is found in pitchblende. The photographic effect may be produced by radium-cards and radium-pencils sold by dealers in such apparatus at a small price.

The electric effect, so-called, is the action of a radio-active substance in rendering the air around it a conductor of electricity. Thus a charge placed on an electroscope will readily escape in the presence

of a radio-active substance. In order to detect the influence of a radio-active body on an electroscope, we have only to make the capacity of the instrument small enough to make the loss of charge apparent. While the activity of a gas mantle can be detected, the influence of a piece of pitchblende is greater. In fact, by projecting the leaves of a small gold-leaf electroscope upon a screen, the effect of the mineral can be observed simultaneously by a number of people.

A CONVENIENT AND INEXPENSIVE ADJUSTMENT FOR GALVANOMETER SCALE

MR. W. H. HAWKES, ANN ARBOR, MICH.

This form of galvanometer scale method is presented as a substitute for the telescope form, especially for high school use, its chief merit being the simplicity in the mounting and adjustment of its parts. The facility with which its reading may be taken and the clearness of its indicator. The scale is near to the operator so that the smallest divisions are easily read and without the exertion attendant upon taking observations through a telescope or some small aperture requiring the use of only one eye and certain facial contortions for a successful operation. The scale may be used with any form of reflecting galvanometer having a concave mirror. It is in no way attached to the galvanometer, resting on its own movable and adjustable support.

The galvanometer carries a concave mirror of about 2 cm. diameter and 30 cm. focus; is placed about 60 cm. from the scale. This distance requires the light to be just in front of the scale support or at about twice the focal distance of the mirror.

The scale may be carried on a strip of ground glass of about 40 cm. length and 5 cm. in width, graduated with lead pencil or India ink to any desired scale, or a paper scale may be mounted on the ground glass trimming the lower edge of the strip to the divisions of the scale. This may be cemented to the upper part of the strip of glass on the side facing the operator. When in use the lower half of the circular field of light will travel just below the scale so that the pointer will fall in with the lines on the scale. By moving this portable scale forward or backward a sharp focus is easily obtained and by moving the scale laterally any zero reading may be adjusted.

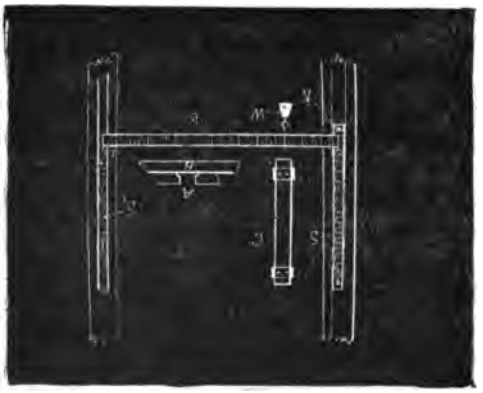
The most accessible and convenient efficient light is the ordinary

Welsbach burner with mantle, fitted to screw into the base of a Bunsen burner. Over the mantle in the place of the ordinary glass chimney a sheet iron chimney somewhat shorter is used. In this, at the proper distance from the bottom, a circular aperture is cut about ½ inch in diameter and across this is soldered a fine wire for indicator. The light with hood then is in no way connected with galvanometer or scale so that in the adjustment of either the galvanometer is not disturbed.

A SIMPLE APPARATUS FOR PARALLEL FORCES

D. F. ROSS, YPSILANTI

This piece of apparatus is designed to overcome an element of error in the experiment of the composition of parallel forces. When the two draw-scales, or coiled springs, used to represent the two forces, are attached to fixed supports there is but a single position for the point of application of their resultant such that the bar will assume a horizontal position; and when the bar assumes an inclined position, the forces are no longer acting parallel with each other, and this inclination is considerable, if the springs are quite sensitive, the nearer this point approaches either of the other forces.



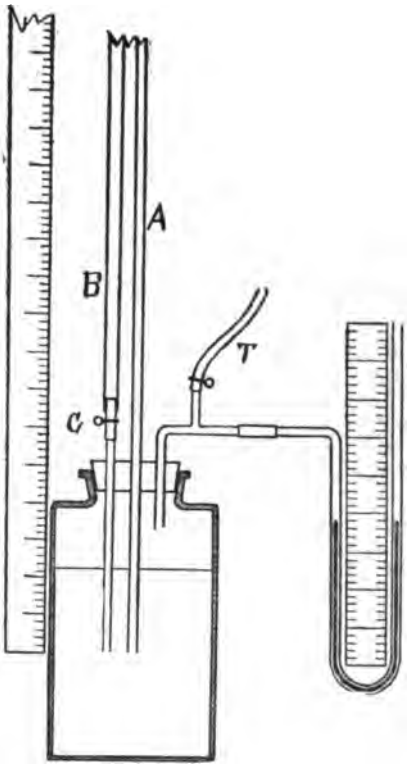
The accompanying figure illustrates a means of overcoming this difficulty, and needs but little explanation to make its action clear. The spring "S" is fastened to a scale which can be raised or lowered as the occasion requires, and held in position by means of the set-screw, "K." "C" is a back view of this sliding scale, showing the two brass plates which project beyond the edges and slide in grooves in the uprights, shown in "A," thus holding it in position and at the same time admitting of a free movement. A scale not shown in the figure, on each upright, enables the student to readily bring the bar into a horizontal position.

The piece is simple, inexpensive, and gives good results.

APPARATUS FOR DEMONSTRATING LAWS OF LIQUID PRESSURE

H. C. KRENERICK, BERWYN, ILL.

With diagram and print, the apparatus will need but a brief description. The tubes, A and B, are a meter or more in length. Tube B is of two parts, so that the upper part can be replaced by tubes of different diameters. The liquid used is a very dilute solution of potas-



sium permanganate. In the print two manometers are shown; one is the open, and the other, the closed form.

The laws which, I believe, can be satisfactorily demonstrated are: That the pressure is proportional to depth, or water-head; that it is proportional to the density of the liquid; and that it is independent of the shape of the containing vessel. The apparatus serves also to show the use of the open and closed manometers.

To demonstrate the first law, use but one tube, clamping off the other by means of the clamp C. By forcing air into the bottle through

the rubber tube T, the liquid can be raised to any desired height in A. When the clamp in T is closed, the column is held, and the readings can then be taken. By varying the height of the column, a series of readings can be obtained. Knowing the use of the open manometer, the pressures can be obtained, and the relation between depth and pressure determined.

To show the effect of a variation in density, fill the tube B with different solutions, the densities of which have been previously determined. The tube is then connected, and the column lowered to a definite or constant height. The readings of the manometer for the different solutions show the expected relation between pressure and density. Care must be taken to lower the liquid until the entire column is of the solution.

The independence of the pressure from the shape of the vessel is easily shown by replacing the upper part of B with other tubes of different diameters, especially with one in which several bulbs have been blown. It is well to experiment also with the tube inclined to the vertical. I believe the most satisfactory and interesting application of the apparatus is the demonstration of this hydrostatic paradox. Students after studying the text are sometimes inclined to disbelieve the principle in all cases. I usually disconnect the larger tube and have some student, by blowing through the tube T, force the liquid as high as he possibly can in the one tube. When the second and larger tube is also in communication with the bottle, he is very much surprised in finding that the two columns can be raised as easily as the one.

The fact that in most text-books the order of topics is such that manometers and related matter are presented somewhat later than the principles of liquid pressure may cause the application of the manometer to be an objection to the use of the apparatus. If such a piece can be obtained, this objection can be prevented and the apparatus very much simplified by connecting directly to the bottle a small pressure gauge in place of the manometer.

BIOLOGICAL CONFERENCE AND SCIENCE TEACHING

LABORATORY WORK AND ITS RELATION TO FIELD WORK

DR. J. G. NEEDHAM, LAKE FOREST COLLEGE, ILL.

The adjustment of field work and laboratory work in any course in biology should proceed upon the assumption that these are complemental and not antagonistic. Their method does not differ necessarily, but only the conditions under which they are carried on. Either may be static or dynamic according to the purpose for which it is used. Both are necessary for the rounding out of most biological inquiries. Both are means, not ends, and should be used accordingly as they serve the pedagogical purpose of the work in hand.

The laboratory has certain great advantages for any work which may be carried on within it. Some of these arise out of our psychological and physical limitations. The laboratory has a roof and a floor and is usable in all weathers. It has walls which shut out distractions. It has tables and chairs whereon we may dispose our members and our implements; and it has conveniences for assembling around us while we work more apparatus and reagents than would be manageable otherwise. Furthermore, it has means of control of light and heat and other forces, useful in experimentation, which cannot be had outside its walls.

These advantages are so great that we take our work into the laboratory whenever possible. There are, however, certain phases of ecology,—distribution studies, and all studies of life in relation to environment *in extenso,* that may not be done within the laboratory, just as there are studies, like histology, which can make no progress apart from laboratory equipment. However, most biological, even most, ecological studies are furthered by the concurrent and complemental use of both field and laboratory; for each with inevitably raise questions best answered by the other.

Life in action is studied in the field; mechanisms and adjustments are worked out in the laboratory. In general, the field gives us our broad conceptions, the laboratory our nearer and clearer views.

LABORATORY WORK IN BIOLOGY—ITS NATURE, CONDUCT AND VALUE*

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Biology was introduced into high schools mostly at the instance of colleges when it was established in the higher institutions. First it was allowed, then required for college entrance and was naturally

shaped after college work. Recently it is being held that biology should be taught in secondary schools in such a way as to be a part of their scheme of giving a more liberal education—to better realize his position in nature—to the youth who cannot hope to go to college.

There is probably as much difference in the nature of laboratory work in biology as there are teachers teaching it, although at first thought there might not seem to be much difference so long as it is laboratory work. Being directed to find certain things in a specimen, and how they "look," and what is their significance is one kind of laboratory work. It is still current in colleges and does less harm there than in the high school. It is a great way in advance of the older text-book method. The pupil becomes a verifier; if he ever attains to more he may thank some innate genius or change of environment.

To begin with, then, specimens are to be placed in the hands of all pupils. Mere observations and descriptions of specimens is not a very enlivening work, but may be made more so by the introduction of experiments that bear on the nature of the specimens studied. It is assumed that both the observational work and experiments will be followed by reading and discussion. Study many specimens, at least in the way of comparison, but require only one or two to be drawn and described. So in experiments, there should be as many as can be done, though only the principal one need be written out. Drawing the apparatus used in experiments is time put in that might be better employed. Nearly half the course should be laboratory work, strictly considered. This would leave the other half to be divided between ecological, or field work, and book work, including the discussion or recitation.

Nearly half the time of any study, especially in the lower grade of the high school, should be for the training of the observation, manual dexterity, and the judgment. To further this end the work should be carefully graded and carefully worded. Only those things that are beyond the pupil's comprehension should be told him and then in such way that he will understand that it is not his own idea; and, what is of no less importance, he should be early taught how to express or to show in his record, what is his own observation or inference and what he has from the book or from his teacher.

The laboratory books that give ready made observations and conclusions for secondary schools are still numerous. This alone would be sufficient reason for every teacher making his own laboratory book. * * * Most of the biological work laid out for second year high school pupils should be simpler. * * * The ideal way would be to have so few students that we might give each student such individual attention. With our large numbers we are compelled to adopt more formal methods, and our pupils are reduced to one level which, I fear, is much below what the best in the class could do. Even if we have such simple and explicit directions that the majority can work

alone somewhat independently, the quality and quantity of work will be below the standard of the better members of the class. We reduce to a common level rather than educate.

We cannot give a pupil all the information that he will need in the future. It would seem better to train him to get information for himself after he has left our sphere. This training will incidentally be half information. Furthermore, mere observation work is not going to do this. After comparisons are made, inferences should be required. And wherever this is susceptible of proof, experiments should be introduced.

All through, both the observations and the experiments must be graded. This does not mean as the science work is arranged in grammar schools, but both observations and experiments must be led up to, or the mind of the pupil prepared for the work. This need not necessarily be done in the book or guide, but may be the part of a good teacher.

"The way" is of more importance than the subjects or the amount of work done. Every observation that is carefully made will assure the observer after each comparison, and lead to more certain knowledge. It gives encouragement to continue along the same line, and engenders confidence in the pupil's ability to try other things. He gains mental traits that cannot be replaced by any amount of mere information not his own. He has had the contact that gives faith founded on experience. Besides furnishing a way of acquiring new facts, it furnishes a way of testing information that seems to be open to question.

MATHEMATICAL CONFERENCE

MATHEMATICS IN AND BELOW THE HIGH SCHOOL

MR. L. D. WINES, ANN ARBOR

I fully realize that I have taken a subject that needs a volume for space and months of time for preparation; but it is with no such broad outlook that your attention is asked at this time. During the past few years much has been said and written about just what should and what should not be taught in Arithmetic, Algebra and Geometry, in our public schools, and much advice has been given as to how these subjects should be taught, and when and where to place the emphasis on each. And yet, from what one hears and one reads, results are still unsatisfactory. The high school teacher is far from satisfied with the results obtained in the grades, and the college professor and business man are far from expressing satisfaction with the greenness and ignor-

ance furnished by the high schools. That the world is far from expressing entire satisfaction with the college graduate is evident enough from the general flood of facetious editorials spread broadcast as often as the month of June appears on the calendar. This last matter is of little consequence just now. For if the college professor and the man in business once come to the point where they are satisfied with the high school product, there will be little cause to find fault with the college graduate.

When the world, including teachers and pupils, takes the same interest and makes as fine discriminations in intellectual training, oratorical and debating contests, prize essays, public discussions and examinations, scientific and literary societies and their researches and results, as it does just now in athletics in general, and I might say in football in particular, then will come the day when little or no fault will be found with the results of either our schools or our colleges. Then also will the day have arrived when no dollar spent for schools and education will be begrudged, and no expense be spared for any legitimate educational project; not even, let us hope, for adequate salaries for the people who are doing the severest and most important work in the world. Perhaps at that time a teacher as well as a washerwoman will be able to ride in an automobile.

A high school graduate is supposed to have spent twelve years in school, during eight of which, in the grades below the high school, he is expected to have mastered about fifty different subjects in arithmetic, extending from notation and numeration through stocks and bonds (things he will probably never see as long as he lives) to a final wind-up with a series of a hundred or more problems, most of which are of such difficulty as to easily frustrate the efforts of not only a college professor, but also of the most astute business man. Of course these eighth graders cannot do what is expected of them; and so in the high school they are asked to go over the whole ground once more, in hopes that finally they will know how to perform the four fundamental operations readily and accurately enough to use them in simple business transactions.

Our committees of ten and various other numbers told us a number of years ago to shorten and enrich the course, and our authors tried to do it, and if there are any differences in results, few have been able to observe them. So again we ask the question, what is the reason the grammar school and high school graduate is not up to what we think should be the proper standard? In fact, what is the proper standard, is perhaps the first question we should answer in order that we may place the fault where it properly belongs. What should a high school graduate know, and what should he be, at least mathematically, when in his seventeenth year, he is presented with the coveted passport to life in the world, or the university, or the college? I trust that because little or nothing is here said about what he should be in general, that

it is not taken for granted that I am not a believer in anything else than mathematics and mathematical training. I believe in "culture" and "education" in their broadest sense; by culture meaning a lively appreciation of all that is "fine in life," in "art, music, literature, courtesy, friendship, and religion," I believe in Spencer's thorough preparation for "complete living," mentally, morally, and physically. Or as Professor Nathaniel Butler says, in the education which makes "training for social efficiency" the goal of a high school course. That the high school graduate should possess above all other attainments a first class knowledge of his mother tongue and an intimate familiarity with both English and American literatures all will admit.

Now, what should this product of the high school know in mathematics? And if he does not know it, whose fault is it?

In Arithmetic he should know that the notation that he uses has a scale of ten, and how to perform accurately and readily the four fundamental operations including integral, fractional, and decimal fractional numbers. This ability should include a thorough knowledge of not only the multiplication table, but also of the addition table; an accomplishment which I have found to be very rare. It does seem as though college boys and girls should be able to add numbers without the aid of the fingers, or without stopping to reason out the value of the sum of two integral numbers each less than ten. This is not all that he should know about these elementary affairs, he should know *thoroughly, very, very thoroughly* all the principles of these four rules, for both integers and fractions. He should know that there is what is called a complex fraction and the most expeditious way to simplify it. I was once told by a university professor that his brightest student in calculus quailed every time he met a complex fraction; and I could easily believe him from my own experience in teaching trigonometry.

This graduate should have a good knowledge of factors and divisors and multiples, of tests of divisibility—including some knowledge of casting out the nines, if for no other reason than that he should not be ignorant of everything that is not generally usuable. Of course he must be familiar with the various weights and measures in daily use; especially should he have a knowledge of the values of the units of the various systems and how they have been obtained, and are preserved and can be restored if necessary. Then ratio and proportion for use in physics, should be thoroughly taught, as should also the subject of mensuration, which for evident reasons should have a very extended treatment. And let me here observe that whatever of geometry it is best to teach in the grades should be taught with mensuration. A brief treatment of involution and evolution should be introduced teaching the method of extracting square root and cube root by stupidly following a rule in each case, leaving the reasons for these processes for the high school course. The course in arithmetic can then be closed up with a treatment of the subject of percentage and its applica-

tions, and, I am inclined to add, a good treatment of allegation, which is so useful in chemistry and physics. This last subject has been tabooed of late years, we are all aware, but from the necessity which Professor Stevens has found of treating it quite fully in his new work in chemistry, perhaps we have been making a mistake.

And now what should he know about algebra and geometry? Briefly, of algebra, what is known "as up to and including quadratics," and of geometry, what is known as plane and solid and spherical geometry, as treated in any one of a dozen or more good geometries that are now published in this country. Lest this should be taken as a wholesale approval of the average treatise of algebra and geometry, allow a few words in detail. The algebra that this high school graduate should study is one that rests every operation on a solid foundation of principles and reasons; one that takes the utmost pains to prove every proposition and establish every principle just as completely as a proposition in geometry is established. It should contain something more than lists of examples and problems, something more than definitions and rules. It should contain demonstrations that are demonstrations, and they should be so clear and so easy to master that they will stay with one as long as he lives. They should be technical in the least possible sense, containing x as little as possible, and using formulas as little as possible. One case will illutrate. In the proof for the various rules for evolution I am most decidedly in favor of the demonstrations as given in the Olney algebra, and am just as much opposed to the way these rules are demonstrated by the author of most any algebra that has been published in recent years. Of all places where you can make the principles of the decimal system stand out and assert themselves, no such other place presents itself in the elementary mathematics. Here you can teach more of the decimal system and hence of other systems than anywhere else. This algebra should contain, and the teacher teach, and the pupil learn, the subjects of equivalence of equations, inequalities and variation. It should also relegate the system of solving quadratic equations by factoring to a back seat, and push forward to its old position the method of solving by completing the square; and after that is thoroughly ground into the bones, then bring forward the methods of solving by formula and the factoring system. The latter I know is a very interesting and at the present time, a very popular method, and should be thoruoghly taught for future theoretical work; but of late years it has been seated on too high a pedestal and should come down. How many cases of quadratic equations which arise in the practical applications of mathematics can be solved by the factoring method, except by a person who is in constant practice? And there is one other subject we must teach thoroughly and as early in the course as possible; that is the subject of logarithms. It should be taught at least as early as the second year in the high school. However desirable an elementary knowledge of the

rectangular system of co-ordinates and its use in the plotting of various loci; however desirable it is to know how to use squared paper, and the slide rule, these and perhaps some other subjects might be somewhat sacrificed to afford time for our students to become familiar with the subject and use of logarithms. The fractional and negative exponent can be introduced by definitions in the arithmetic, and logarithms made accessible to students much earlier than is now done.

As to the kind of geometry this high school pupil must master, little needs be said. Several thousand years' use of practically one text has crystalized the subject so that no book is likely to be used can lead us far astray. It is now thoroughly understood that plenty of problems for original solution and demonstration must be introduced to sell any book on geometry. There is one point on which we cannot be too careful and that is not to undertake to generalize too early. It is also a question as to how much of the advanced or modern geometry it is best to introduce; but lack of time in the course will not make an appreciable amount possible. It should not be forgotten that geometry as studied in the high school is not for the sole purpose of preparing a boy or girl for the university. It is not to teach him geometrical facts primarily; it is to teach him to use his mind, and keep it on his business; in a word, to teach him to think, i. e., to teach him to teach himself, the common end of all true teaching.

Now that we have before us what a high school graduate may fairly be expected to know in mathematics, and, having previously admitted that in general he does not know it, the question arises, where does the fault lie? My answer is principally in two parts. It is partly his own fault and partly the fault of his parents and his teachers, but mostly his teachers' fault.

During my connection with the Ann Arbor High School it has been my lot to come in contact with many pupils from many different schools of many different states, as well as to meet daily the pupils who have come into the high school from our own city; and I can assure you that it is as important for the average boy or girl to come from the hands of good teachers as it is for them to come of good parents. I have said that the pupil is partly to blame, and it is true; for unless the pupil makes a conscientious effort, no matter how intensely the teacher tries to teach, little can be accomplished.

It is certain that heredity and environment working through personality are of great value to every one of us all through life, but as we cannot select the ancestors of our pupils or control to any large extent their environment, we must do as we have always done, take them as they are and do our best.

In what respects then are the pupils responsible for their great mental poverty when about to leave the high school? Among all the reasons I can give, what is called lack of will power is perhaps the most fundamental. This deficiency seems to be at the bottom of all

their shortcomings. They do not, in fact they will not when studying, do as they are advised; they will not stick to a sentence or a paragraph till they strike bottom; they will not learn things thoroughly; they will not aim at something, and with their mind on the mark, strive to hit it. On every teaching day of my life I am obliged to listen to pupils try to recite in geometry who do not know the hypothesis, who do not know the conclusion, and of course do not know, nor do they seriously strive to find out, what must be done to prove the proposition; and yet they want to recite, and they want to get through, and they want to graduate. Whether they want to know something is another question. In the solving of problems in either arithmetic, algebra or geometry they persistently refuse to give nine minutes to the study of the problem, trying to discover the relation of the involved quantities, and then take one minute for the solution. They much prefer to take nine minutes for the solution and none for discovery. They rebel against doing the necessary amount of "dead" work in any of the mathematical subjects which they study. Out of a page of twenty--five or thirty problems if they solve the first, tenth and last they think they have done wonders, and some time later when an accurate knowledge of this subject becomes necessary for further advance, they say they have forgotten. No, they have not forgotten; they never had a chance to forget. Another reason why many of our students do not remember their mathematics is because what little they may have known they did not know in the right way. Again, many are willing, and do immense quantities of "dead" work, and take pains to learn things in the right way; and when they leave school they know very much of what they have learned. I have seen some of these students of the latter class who could, twenty years or more after leaving school, solve problems in arithmetic and algebra with nearly as much facility as when in school; even though they had not gone to college or followed teaching or any other calling than business.

And yet again, many of my students would get as many ideas out of a paragraph if they read it backwards as they do in reading it as printed. They seem to have cultivated the art of sounding the printed words properly, but not the art of gaining ideas when they read and study. Strive as hard as one may day after day to teach them that this is folly, they seem illy to realize it. This does not appear to be natural, and one can hardly avoid feeling that there is some good reason for it. Whether the methods used in the kindergarten have been practiced all along the course and have left the pupils in a sieve-like condition, is hard to say. One thing many of us do believe, and that is that kindergarten methods do not develop the will power. However evident it is that "The mind always sees clearly what it really sees, and that we reason amiss only when we speak of what we do not see," however evident this is made to appear, many pupils will try in the next breath to reason and become most heartily discouraged

because they cannot master an idea which they will not allow to enter the mind. The case of the pupil then is simply this: he dislikes immensely to use his brains, and will not do it so long as he can avoid it.

It must not be inferred from the foregoing that all high school students are mentally incorrigible; for it is not so, and the many good and true souls who do their best and who succeed in acquiring a good education are numerous enough to make all our efforts worth while. That more of them are not successful is not alone their fault.

And now how much is the parent and the teacher to blame for the poor results obtained by our schools? That fathers and mothers are responsible as parents and as members of our school boards, to some extent, all will admit. If one could visit the homes of many of our pupils much could be explained and much excused. Still when the conditions seem best, as far as home surroundings go, the pupils are often poorest, and when home surroundings seem poorest the pupils are often the best. That errands must be done, and dishes must be washed, and babies must be tended, are of course conditions not conducive to good scholarship; but if these were the only influences working against scholarship in the home it is quite certain that high school teachers, at least, would not have much cause to complain. The social obligations, the fraternity meetings, the mid-week parties and entertainments of all characters, at inopportune times, are the things that shatter scholarship, and many times also impair good health. The father and mother in the capacity of parents can and should confine these necessary pleasures to reasonable limits and rational hours and times. In the capacity of members of the school board the parents also have serious and responsible duties to perform, not the least of which is to furnish plenty of first-class teachers at reasonable pay. Last semester in talking with one of our students who came from a nearby town, and who had been failing in his algebra, I took occasion to inquire a little into his hisotry. He told me that he had studied algebra one year before coming here. He was first classified in Algebra 3, failed there, and put back into Algebra 2, failed there, and put back into Algebra 1. I asked him what he thought the matter was. Well, he did not know. Didn't you have a good teacher in the school you came from? Why, yes, but she had seventy-five pupils in her room, and I guess she did as well as she could. I think she did. The parents in that community need to think a little more of their children and a little less of their dollars. No teacher should ever have more than twenty-five pupils at a time. A state law obliging boards to pay minimum salaries, and an additional dollar per week per pupil for more than twenty-five children, would have a salutary effect on the product of our schools. The state could reasonably exact this condition now that the primary school fund is so large.

Lastly, what about the share of responsibility for poor results can reasonably be placed upon the teacher? If I was asked to name the

per cent of responsibility that might justly be attributed to him, I should answer anywhere from seventy-five to ninety percent, depending on other conditions, some of which have already been mentioned. Emerson says that "What we most need in this world is somebody to make us do what we can do; this is the work of a true friend." Of course this also means, to show us what we ought to do and then make us do it. As I look back over my school days, the studies I did best in, and learned most about, were the ones in which I had good teachers. Of these there were, unfortunately for me, only three, and one of these was my algebra teacher in the eighth grade. One can almost say that everything depends upon the kind of teachers we have. It is true that some scholars will do well with any kind of a teacher, and some will learn in spite of their teachers, but most of us need wise and constant attention. A student in review algebra once made in substance the following statement: "I had a certain part of the algebra with A. and a certain part with B.; somehow I remember what I had with A., but I do not remember anything about the part I had with B. The same boy, the same subject, but not the same result.

Here then is the first thing a teacher must be able to do to be efficient and successful. He must be able to secure earnest work on the part of his pupils. If the majority of pupils will not work at home, or before coming to class, they must be made to work in the recitation room to make up for it; therefore the teaching cannot be allowed to take on the character of telling, but of making them *tell* you. The operation by which this is done is sometimes called pumping, and if ever you have tried it you have found it to be hard work. That many of our students learn to question themselves systematically and successfully as the result of the constant efforts of their teachers, there is no doubt; and that wise questions and correct answers have been at the root of all success is equally evident, and could be easily illustrated.

The questioning method of teaching is the one that brings the teacher into close contact with his pupils and determines whether or not the pupil has been in close contact with his lesson; and it might also be observed, whether the teacher has been in close contact with his subject. There is not enough pains taken, all through the high school, at least, to see to it that every capable student does the work that is set for him to do. It takes time and hard work to look over examination papers, as well as other set tasks; but in this way only can a teacher be sure that each pupil has done the necessary work, especially in mathematics. I think I will tell how I once saw a teacher fail to make contact with his pupils. It was in a recitation on a day when the lesson consisted of a certain number of problems (not examples). On entering the room the scholars were all sent to the board and each given a problem to solve. The teacher took a seat and waited for results. One after another, some of the solutions were completed, and the teacher, armed with a set of answers, indicated whether the

answer was right or wrong. If it was right, the problem was immediately erased by the pupil and another assigned for solution. Not one question was asked, not one thing was done to determine whether the solution was a satisfactory one, or whether it was a solution at all. All that the teacher knew was that at the close of the writing on the board was the same number that was found on a certain page and line of the answer book. The pupil could have found this out with the answer book without the aid of the person who was supposed to be a teacher. At the close of the recitation period, not one-half of the students had finished their problems; but a new lesson was assigned for the next day, when it is fair to suppose the same operation was gone through with as before. Not one person in this hearing calls this teaching, not one here present but knows that such work is a fraud, and the teacher who teaches in this way is the worst kind of a grafter; nothing but a drawer of breath and a drawer of salary. And I will guarantee that though there was enough breath drawn, there was drawn too much salary, however small it may have been. This was infinitely poorer teaching than my teacher of algebra used to do in the high school when she would determine if we had solved our examples right by comparing our solutions with hers which she had written out on paper. To simply do in mathematics, to get the answer, is not the only thing desirable, even when you do right and get right answers. To know how it is done and know why it is done are of more importance. To have the right answer is important, but it is the last thing of importance. For the university boy or girl, as well as for the school boy or girl, there is nothing more important than the why, than the theory. To study the problem and discover relations, to talk before the class and explain these relations are things of the utmost importance, and any teacher that does not devote more than half the recitation period daily to this kind of work is failing and giving plenty of reason why high school boys and girls are so poorly equipped.

To take each equation in a solution and fully tell how you obtained it, and the next equation following, stating the principles used and telling all about it, are the things that are worth doing; these are the things that will stay with one through life, that make mathematics a live subject, and a powerful subject for intellectual development and discipline.

In contrast to this method of teaching is the method sometimes used by mathematical sharks who constantly strive to impress their own great mathematical superiority by using and teaching short cuts. On this point I wish to quote a few sentences from the preface of Finkle's "Mathematical Solution Book": "It will not be denied by any intelligent educator that the so-called 'short cuts' and 'Lightning Methods' are positively injurious to beginners in mathematics. All the 'whys' are cut out by these methods and the student robbed of the very

object for which he is studying mathematics, viz., the development of the reasoning faculty, and the power to express his thoughts in a forcible and logical manner. By pursuing these methods mathematics is made a memory drill, and when the memory fails, all is lost; whereas it should be presented in such a way as to develop the memory, the imagination, and the reasoning faculty. It cannot be denied that more time is given to, and more time wasted in the study of mathematics in our public schools than in any other branch of study. The reason for this, to my mind, is apparent. Pupils are allowed to combine the numbers in such a way as to get the answer, and that is all that is required. They are not required to tell why they do this, and why they do that, but, 'did you get the answer?' "

Mathematics taught and learned in the right way cannot easily be forgotten. But even though much of its detail may slip away from us, the mental results are as lasting as the everlasting hills. Disciplinary results are what we must strive for in all teaching. This injunction is now laid upon us with as much if not more force than in the days when the number of classical graduates from our high schools outnumbered all other courses. At present, as you all know, the egineering section is the largest; and even though this condition would seem to call for better students in mathematics than formerly, there are many who honestly believe that we do not have as many good students in mathematics now as we used to have when more were studying Latin and Greek, and fewer were playing with "fads and fancies."

This being better teachers, and bringing our students closer to their work and ourselves and making them familiar with all its details, is in the air all about us; and we teachers of mathematics in the public schools must not fail to have it include us. Old methods that have failed or have outlived their usefulness must be cast aside, and the new ones adopted. Only recently, Dr. Darling, of our medical department, told me that he had discarded old methods of instruction, and that now instead of trying to teach by the wholesale and at arm's length, he takes four students into the operating room with him, and they not only see but help him and tell him what to do. So we must take our students with us and interest them deeply in their work and our work, if we wish to accomplish worthy results.

There are numerous other reasons why we are not producing satisfactory results; but time forbids that I should more than mention two or three of them.

Many times we make the mistake of assigning problems that are too difficult for our students, and to advance them to a higher grade before they have completed the work of the lower grade. A teacher of music is very careful not to give a pupil a piece of music that is too difficult. If she does, disaster is meted out instantly. We teachers of mathematics should be equally wise, and not give our students work that is too difficult for at least the average pupil in the class. For this

reason it is very necessary that the proper kinds of texts should be used in the various parts of the course. Three grades of arithmetic and two of algebra should be provided. There is no doubt at all but what we are making a very serious mistake when we undertake to teach the beginners in algebra from the same text as that used by those who are completing the subject. My experience on this point is such as to make me feel positive that it is a very grave error for us to continue longer in this course. We should by all means use an elementary text with the beginners.

Another reason why we fail to produce desired results is because of the time when these subjects are taught in our courses. The arithmetic taught in the grades should be completed by the end of the first half of the eighth year. If some geometry, so-called, is taught in this year, it also should be out of the way by this time, and the study of algebra should be begun and continued for the remaining half-year, and the work in mathematics continued in the high school about as follows:

8		9		10		11		12	
	Alg.	Alg.		Arith. & Logs.		Alg.	Alg.	Geom.	Geom. & Rev. Alg.

or as follows:

8		9		10		11		12	
	Alg.	Alg.		Arith. & Logs.	Alg.	Alg.	Geom.	Geom.	Trig. & Rev. Alg.

It will be noticed that little or nothing has been said about the teaching of geometry. The truth is that most that has been said is just as applicbale to geometry and trigonometry as to arithmetic and algebra. Geometry is to a large extent a disciplinary and a culture study; although its practical applications are just as numerous and just as useful as are those of the other mathematical subjects. Geometry is harder to teach and harder to learn, and its problems more difficult for high school students to solve than are those of the arithmetic and algebra, and yet it is probably true that more students fail in their advanced work in mathematics in college through a poor preparation in algebra and arithmetic than for any other cause.

It will be noticed that I have said nothing about the amount of mathematics required of our graduates either for graduation into business or for entrance into college. I have nothing to say, except that I think the requirements for either or both are just about what they

should be, even though there is some agitation in the east to reduce the amount for entrance to college.

In conclusion, "knowledge" has been defined as the "Abiding result of some action of the mind." It is theerfore necessary if we wish our pupils to acquire knowledge we must see to it that their minds are put in action. They must do their share, and I hope I have made it clear that the teacher must do his share.

HISTORY CONFERENCE

REPORTED BY EDITH M. KIMBALL, DETROIT EASTERN HIGH SCHOOL, SECRETARY OF THE HISTORY GROUP

The principal features of the meeting of the History Group consisted of the first report of the Committee on Recent Publications of Interest to Teachers of History, read by the chairman, Principal Webster Cook, and an address by Professor Andrew McLaughlin on "The Significance of Party Organization in American History." The greater portion of Mr. Cook's report is given in this number of the Proceedings. It is with intense regret that we are unable to publish the characteristically interesting "talk" given by Professor McLaughlin.

In the business meeting, a constitution was proposed by the Committee on Organization, and adopted. This was the result of a feeling among those interested in the history of the Michigan Schoolmasters' Club, that a closer organization of that group ought to be effected, and an effort made to gain the active co-operation of all those interested in historcal study. The great dfficulty to be encountered in bringing about an effective organization is, that so large a number of those teaching history are doing so simply to fill up their hours, and expect to drop out of it in a term or two. Then, too, many teach history who are planning to leave the profession for others for which they are fitting themselves in the meantime. These teachers, of course, cannot be interested in anything to further the development of historical study. This condition is felt to be in a sense peculiar to the history work. One hardly undertakes to fill in hours with science or language unless he has had some special preparation or interest in the subject, but any one may have an hour or two of history given him to teach, though his specialty may be language, science or athletics.

Because so large a proportion of the teaching force is variable and uncertain, it seems doubly urgent that those who are truly interested in the development of historical study should take a very active part in planning for its furtherance. To this end the committee presented

a constitution, to serve merely as a working plan, not considering it complete or even adequate, but hoping thereby to accomplish an organization which can develop or change it, as becomes necessary.

CONSTITUTION

Article I—Name and Purpose

This body shall be known as the History Group of the Michigan Schoolmasters' Club. Its purpose is the advancement of the study of history as a means of education.

Article II—Membership

Any person who is eligible to membership in the Michigan Schoolmasters' Club and who is interested in the advancement fo the study of history as a means of education, shall be eligible to membership in the History Group.

Article III—Officers

The officers of this body shall be a chairman and a secretary, to be elected at the annual meeting, and an executive committee consisting of the above named officers, together with five other members to be appointed by the chairman. The executive committee shall have general direction of the work of the group.

Article IV—Meetings

The annual meeting shall be held at the time of the annual meeting of the Michigan Schoolmasters' Club. All questions in regard to the holding of any other meetings shall be subject to decision by the executive committee.

Article V—Process of Amending

This constitution may be amended at any annual meeting by a two-thirds vote of the members present, provided that the proposed amendment is recommended by the executive committee.

Acting in accord with this constitution, the group chose as chairman for the ensuing year, Professor Earle W. Dow, of the University, and as secretary for the same period, Miss Edith Kimball, of the Detroit Eastern High School.

The chairman appointed to be members of the executive committee for 1906-1907, along with the chairman and secretary: Miss Mary B. Putnam, Normal College; Professor G. W. Bell, Olivet College; Principal Dean Lawrence, Alpena; Miss Mabel Steward, Michigan Seminary, Kalamazoo; and Mr. J. B. Davis, Detroit Central High School. As members of the committee on "Recent Publications of Special Interest to Teachers," he appointed Principal Webster Cook, of Saginaw,

chairman; Professor A. L. Cross, of the University; and Mr. Charles Estrich, of the Northern State Normal, Marquette.

The round-table conference on the work in ancient history, confined itself to the discussion of (a) How may we best secure the interest of the first year pupils? (b) To what extent should we teach the constitutional history of Greece and Rome in the first year? The general opinion, as expressed, seemed to be that as the year in ancient history is the only history that half or more than half of the pupils ever have, it seems necessary so to interest them in historical study that more will desire to continue the study, or be eager to read along that line.

In order to create interest it was suggested that the dramatic side be emphasized, causing characters and individuals to stand forth, the conditions and times being understood through them; also that the child be helped to place himself in the atmosphere of the people whom he is studying, by means of visual and word pictures, and narrative in the first person.

The opinion seemed to prevail that constitutional history, to the extent presented in an ordinary text-book, could be taught without loss of interest, and with understanding. That the general functions of our own government should first be made clear; whenever possible, comparisons should be made, and the pupil made to understand why changes take place, and just what changes follow certain conditions.

THE REPORT OF THE COMMITTEE ON RECENT PUBLICATIONS OF INTEREST TO HISTORY TEACHERS

In his report Mr. Cook mentioned new editions of Bryce's "Holy Roman Empire"; Henderson's "History of Germany," in one volume; "Traill's Social England," and the Autobiography of Andrew D. White. He called special attention to several works newly brought before the public. To quote him:

"The first one I will mention is the 'Historians' History of the World,' put on the market in this country by the Outlook Company. This is a work of twenty-five volumes and is peculiar in one important feature. It is made up mainly of direct quotations from the great historical writers, so woven together as to give a continuous narrative. What I have to say about this and the other works that I shall mention is solely from one point of view, that of the value of these works as reference books in connection with our classes in American history. I am not attempting to make a general criticism.

"As its title indicates, this is a history of the world from prehistoric times down to the election of President Roosevelt in 1904. It is thus the history of many different peoples, of many different times and places. It results that not very much time can be given to any

one time or nation. It is not a treatise on any particular subject or phase of history, and is not full enough in its detail to be placed under the head of valuable works. For example, let us examine the history of the United States. If we leave out of consideration the preliminary material which would not be found in an ordinary text-book, the space devoted to that portion of the history used in schools is not much greater, for example, than that in Channing's 'Student History of the United States.'

"But there is a more serious difficulty in connection with this work. The text is made up mainly of quotations from various authors, some of them of considerable length, some of them very short. It sometimes happens that a single paragraph is made up of a number of quotations strung together. Now every author has his own point of view, his own attitude towards his subject, and it thus happens in a paragraph so constructed that the point of view is constantly changing. Perhaps the experienced reader can allow for this constantly changing tone and weigh the paragraph accordingly. But the high school student cannot, and what should be the real and proper effect of the paragraph is consequently lost.

"A similar difficulty applies to larger portions of the work. Let us take, for example, the treatment of Columbus. A not very successful attempt is made at the beginning to give both sides of Columbus' character. He was not all bad or all good. On his bad side he is said to have been no worse than Bobadilla, who at one time made him so much trouble. Further along Bobadilla is spoken of as one of the vilest of men, in sharp contrast with Columbus' virtues, and in the end Columbus is eulogized as one of the very greatest of earthly heroes. Such changes in tone and spirit the experienced reader again may be able to allow for, but they utterly unfit the book for a reference book for high school pupils.

"I next want to speak of a work that has just come to hand. It is entitled 'Great Events by Famous Historians,' and is made, according to its title page, on a 'plan evolved from the consensus of opinions, gathered from the most distinguished scholars in America and Europe,' and is a 'comprehensive and readable account of the world's history,' a 'complete narrative in the master words of the most eminent historians.' The work is edited by Rossiter Johnson. This is a work of twenty octavo volumes, excellently bound, and with illustrations partly in colors taken from famous paintings.

"The first volume I happened to examine covered the period from 1861 to 1872. The first article in this volume is a brief, general account of this period, too brief to be important. The next topic is entitled 'Secession of the Southern States." The two authors quoted from are Jefferson Davis and Abraham Lincoln. The selection from Davis is taken from his 'Rise and Fall of the Confederate Government,' and from Lincoln are given his inaugural address, and his first message to

Congress. All these selections are inconsistent with the title page. Neither of these writers is a historian, nor are the selections history. They all furnish much material from which history might be made, and if the work were made up entirely of such, it might be valuable as a source-book, but the other selections are of a different kind.

"Other topics, taken in order given in the book are: 'The Battle of Bull Run,' by Horace Greely; the 'Monitor and the Merrimac,' by John D. Champlain; 'The Capture of New Orleans,' by Royal Farragut· 'McClellan's Peninsular Campaign,' by Rossiter Johnson; 'Emancipation,' by Abraham Lincoln, etc., for twenty-four other topics. As there are less than four hundred pages in the volume, the selections average about a dozen pages each.

"From this it is evident that this is no consecutive history at all. In connection with our great Civil War, for example, about a dozen battles are described. The real progress of the war is nowhere shown, nor is its character nor its results. If one wants a series of brief articles for entertaining reading, the work abounds in them, as many of the accounts are excellent, though not all are reliable. But for serious work it is useless. It has no place among reference books for the school."

He then calls attention to a work of an entirely different kind, Professor Osgood's "American Colonies in the Seventeenth Century": "'It is intended to exhibit in outline the early development of English colonization in its political and administrative side. At the same time it is a study of the origin of English-American political institutions.' It shows the various phases through which colonization schemes passed, it shows the difference in the character of the various grants and charters, and in the resulting settlements, and traces the various movements out of which the institutions gradually developed. Even from the point of view of general history, this work furnishes much valuable information, and must rank among the best of reference books for our earliest history." Attention was also called to the "American State Series," edited by Professor Willoughby, and published by the Century Company.

SYNOPSIS OF BUSINESS MEETING

UNIVERSITY HALL, March 31, 1906.

The meeting was called to order by President A. S. Whitney. The minutes were read by the secretary, Louis P. Jocelyn. Reports were made by the secretary, the treasurer, J. P. Everett, and the chairman of the auditing committee, E. A. Lyman.

REPORT OF AUDITING COMMITTEE.

Total receipts in hands of the Secretary		$499.66
Total receipts in hands of the Treasurer		57.00
Total		$556.66
Total disbursements by the Secretary		$423.05
Total disbursements by the Treasurer		57.00
		$480.05
Balance on hand March 1, 1906		76.61
Total		$556.66

Accounts found correct.

E. A. LYMAN,
C. W. MICHENS,
Auditing Committee.

FINANCIAL REPORT OF THE SECRETARY.

Receipts.

March 22, 1905	Balance	$ 17.16
March 23, 1905	Deposited fees	19.00
April 1, 1905	Deposited fees from Treasurer	326.70
April 8, 1905	Deposited fees	13.00
July 22, 1905	Deposited fees	3.00
Nov. 18, 1905	Deposited from U. of M.	70.00
Dec. 28, 1905	Deposited	.80
Feb. 10, 1906	Deposited from Normal College	50.00
Total		$499.66

Disbursements.

April 7, 1905	Cheque No. 20, piano	$ 5.00
April 7, 1905	Cheque No. 21, Prof. L. H. Bailey	33.35
April 8, 1905	Cheque No. 22, moving piano	5.00
April 8, 1905	Cheque No. 23, postage	2.00
April 13, 1905	Cheque No. 24, clerk hire for year	21.20
May 6, 1905	Cheque No. 25, printing account	129.45
May 16, 1905	Cheque No. 26, janitor	2.00
July 22, 1905	Cheque No. 27, badges	4.50
July 22, 1905	Cheque No. 28, postage	2.00
Oct. 17, 1905	Cheque No. 29, postage	5.00
Oct. 23, 1905	Cheque No. 30, postage	2.40
Oct. 24, 1905	Cheque No. 31, postage	3.00
Dec. 28, 1905	Cheque No. 32, printing account	100.00

Dec.	29, 1905—Cheque No. 33, printing account in full	96.90
Jan.	13, 1906—Cheque No. 34, postage	2.00
Jan.	13, 1906—Cheque No. 35, stationary	3.25
Feb.	7, 1906—Cheque No. 36, Michigan Passenger Ass'n	6.00
	Total	$423.05
	Balance on hand March 1, 1906	76.61
	Total	$499.66

REPORT OF THE TREASURER.

Receipts.

March 22, 1905—Balance	$123.16
Received from dues	277.70
Received from the Secretary	155.80
Total	$556.60

Disbursements.

March 30, 1905—Paid Pres. Woodrow Wilson	$ 45.00
April 1, 1905—Paid Prof. James R. Angell	12.00
Paid through the Secretary	423.05
Total	$480.05
Amount in bank, balance March 1, 1906	76.61
Total	$556.66

NOMINATING COMMITTEE.

Appointed Friday Morning, March 30.

S. O. Hartwell, representing the club at large—Kalamazoo.
L. P. Jocelyn, representing the club at large—Ann Arbor.
F. W. Kelsey, representing Classical Conference—University.
H. M. Randall, representing Physics Conference—University.
W. S. Leavenworth, representing Chemical Conference—Olivet College.
Mary Goddard, representing Biological Conference—Normal College.
J. L. Markley, representing Mathematical Conference—University.
J. B. Davis, representing Historical Conference—Detroit.
Clyde Ford, representing Modern Language Conference—Normal College.
C. B. Merrill, representing English Conference—University.

REPORT OF THE NOMINATING COMMITTEE.

President, David Mackinzie—Detroit Central.
Vice-President, Miss Lucy Sloan—Central Normal.
Secretary, Louis P. Jocelyn, Ann Arbor.
Treasurer, John P. Everett—Mt. Clemens.

Chairman of the Classical Conference—J. H. Drake—University.
Secretary of the Classical Conference—B. L. D'Ooge—Normal College.
Chairman of the Physics Conference—N. F. Smith—Olivet College.
Chairman of the Chemical Conference—B. W. Peet, Normal College.
Secretary of the Physics and Chemical Conference—De Forest Ross—Ypsilanti.
Chairman of the Mathematical Conference—C. B. Williams—Kalamazoo College.
Secretary of the Mathematical Conference—L. C. Karpinski—University.
Chairman of the Modern Language Conference—A. G. Canfield—University.
Secretary of the Modern Language Conference—Ernest Lutz—Albion College.
Chairman of the Historical Conference—E. W. Dow—University.
Secretary of the Historical Conference—Edith Kimball—Detroit Eastern.
Chairman of the English Conference—J. H. Harris—Pontiac.
Secretary of the English Conference—Cornelia Hulst—Grand Rapids.

Chairman of the Biological Conference—S. O. Most—Hope College.
Secretary of the Biological Conference—Ella Bennett—Ann Arbor.

Mr. B. A. Finney of the University made a report of the Committee on the Conditions of the Libraries of the Schools of the State. The report was accepted, and the Committee continued.

A vote of thanks was extended to all who assisted in making the meeting one of the best in the history of the Club.

COMMITTEE ON NEW CONSTITUTION AND BY-LAWS.

*J. O. Reed—University.
L. P. Jocelyn—Ann Arbor.
David Mackinzie—Detroit.
J. H. Drake—University.
E. A. Lyman—Normal College.

*On account of illness Mr. Reed did not act on the Committee.

In the absence of the Chairman, through illness, the Secretary read the report of the Committee on a New Constitution and By-Laws and after a few modifications the report was accepted and adopted and made the governing laws of the club. The report as accepted and adopted is as follows:

ARTICLES OF ASSOCIATION OF THE MICHIGAN SCHOOLMASTERS' CLUB

ARTICLE I—*Name*

The association shall be known as the Michigan Schoolmasters' Club.

ARTICLE II—*Place of Office*

The office of the club shall be located in the city of Ann Arbor.

ARTICLE III—*Object*

The object of the club is to further the common interests of the schools, colleges and university of the state.

BY-LAWS

ARTICLE I—*Time and Place of Meeting*

The club shall hold an annual meeting in the city of Ann Arbor. The time of meeting shall be determined upon by the Secretary upon the advice of the Executive Committee.

The general meetings of the club shall be held on Thursday and Friday mornings, and the conferences of the club may be held at any time during the same week except on Thursday and Friday mornings.

ARTICLE II—*Membership*

Any person actively engaged in any branch of educational work may become a member of the club upon payment of the annual or life membership dues. A person ceases to be a member of the club when his annual dues remain unpaid one month after the last annual meeting.

ARTICLE III—*Dues*

The annual dues of the club shall be one dollar; life membership ten dollars. All life membership dues shall constitute an endowment fund and shall be placed at interest.

ARTICLE IV—*Officers*

The officers of the club shall be a President, Vice-President, Secretary, Treasurer and an Executive Committee.

ARTICLE V—*Election of Officers*

On the first day of the general meeting the president shall appoint a committee composed of three members from the general session and one each from the different conferences, to present candidates for all

officers of the club, including the chairmen and secretaries of the different conferences. Each committeeman representing his conference shall present the names of candidates nominated for office by his particular conference, and in case no such nominations are made *he* shall make the nominations.

The committee as a whole shall nominate persons for the positions of President, Vice-President, Secretary and Treasurer of the club, and shall receive the nominations made by each conference, or by its committeeman, and shall be sole judge of the qualifications of each nominee.

No person shall be elected to any office who is not a member of the club, or whose dues for the coming year are not paid, or who has held the office to which he is elected for the two previous years. The time limit of this law shall not apply to the positions of Secretary and Treasurer.

ARTICLE VI—*Time of Election of Officers*

The time of election of officers of the club shall be on the morning of the last day of the general meeting.

ARTICLE VII—*Method of Election*

Unless otherwise ordered the election of all officers shall be by ballot.

ARTICLE VIII—*Tenure of Office*

The general officers of the club, except the Secretary, shall be for one year; those of the conferences, except the Secretary, for not more than two years; and all officers shall hold office until their successors qualify.

ARTICLE IX—*Duties of Officers*

(a) *President*

It shall be the duty of the President to preside at the annual meetings and at the meetings of the Executive Committee. He shall be responsible for the program of the general sessions of the club, and shall perform such other duties as generally pertain to the office of President.

(b) *Vice-President*

It shall be the duty of the Vice-President in the absence of the President to perform all the functions pertaining to the President. He (she) is a member of the Executive Committee.

(*c*) *Secretary*

The Secretary shall be the permanent officer of the club and shall be responsible for the general welfare and policy of the club. He shall have general supervision of the club when not in session, and, with the President and the Chairmen and Secretaries of the different conferences; shall be responsible for the nature and plan

of all programs issued by the club and the proper distribution of the same. The Secretary shall have power to collect, to hold, and to disburse, in the interests of the club, any money in his possession belonging to the club. Provided, however, that he shall deposit in a bank all money received and, further, that he shall pay out money only by check detached from the usual stub-form. It shall be his duty to give, each year, to the auditing committee, a written financial statement of his account with the club. He shall turn over to the auditing committee the bank stub-book and the canceled checks, which stub-form and canceled checks shall be returned to him. He shall also furnish the Treasurer of the club a duplicate of his report to the Auditing Committee, which report the Treasurer shall make part of his own report.

The Secretary shall read his financial report at the business meeting of the club, and shall also give an annual report of the general condition of the affairs of the club.

He shall have charge of the records and correspondence of the club, and shall keep a list of all teachers who attend the meetings and of all persons taking part in its programs.

He shall collect for publication the addresses delivered and the papers read before the club and before the different conferences, unless otherwise provided for. He shall edit the official proceedings, have them printed in proper form and shall distribute the same to the members of the club.

To assist him in the performance of his duties, the Secretary shall be allowed a definite salary, the amount of which shall be determined upon each year by the Executive Committee.

(*d*) *Treasurer*

The Treasurer shall have power to collect dues and pay out in the interests of the club any funds in his possession. Before the annual meeting he shall prepare a financial report for the Auditing Committee and shall read such report at the business meeting, and turn the same over to the Secretary for publication in the proceedings.

The Treasurer shall receive an account of the receipts and disbursements of the Secretary and shall incorporate the same in his report. He and the Secretary shall deposit all money belonging to the club in the city where the office of the club is located. After money is deposited in the bank by the Treasurer he may draw out any portion of the same by an order on the Secretary.

(*e*) *The Executive Committee*

The Executive Committee shall be composed of the President, Vice-President, Secretary and Treasurer of the club, together with the chairmen of the different conferences. It shall meet upon the call of the Secretary of the club and shall be entrusted with the general

policy of the club. It shall have power to fill all vacancies occurring when the club is not in session, to settle all controversies, and, in general, it shall have charge of all of the weightier matters of the club.

ARTICLE X—*Conferences of the Club*

All conferences shall be under the general management of the club. Their control and general policy shall be in the hands of the Executive Committee. Their Chairman shall be chosen every year and no person may act as Chairman of his particular conference for more than two years in succession. Their Secretary may be elected for a period of three years.

The Chairman of each conference is a member of the Executive Committee. No person shall be elected to any office in the conference who is not a member of the club or who is in arrears in dues. (This clause does not restrain an official Chairman from appointing any person as Acting Chairman at any particular session.)

Each conference in turn shall be assisted by the club in arranging a special program. To this end the Secretary of the club shall enter into an agreement with the Chairman of such conference to furnish funds (to a reasonable amount) to bring before the conference the most eminent men in their particular line of work. The conference holding this special session may be allowed more than the usual time required for its meetings.

ARTICLE XI—*Auditing Committee*

The President shall appoint each year two members of the Executive Committee to examine the accounts of the club and to report the condition of the same at the annual meeting.

ARTICLE XII

These By-Laws may be amended by a majority of the members present at any annual meeting upon twenty-four hours notice being given.

PROGRAM OF GENERAL SESSIONS

Friday Morning

1. The Educational Import of Modern Thought,
   Professor John T. McManis, Western Normal.
2. Evolution and Moral Education,
   Dr. Theodore de Laguna, University of Michigan.
3. The Nature of the Child,
   President E. G. Lancaster, Olivet College.

Friday Afternoon

President W. O. Thompson, University of Ohio.
Young Ladies' Class in Gymnastic Drill and Basket Ball Game.

Friday Evening

Concert, by Sousa's Band.

Saturday Morning

1. Over-Pressure in High Schools,
   Mr. Jesse Davis, Central High School, Detroit.
2. Self-Activity in Education: Its Meaning and Conditions,
   Professor John Dewey, Columbia University.
3. Business meeting.

PROGRAM OF CONFERENCES

CLASSICAL CONFERENCE

Thursday Morning

1. Latin in Michigan High Schools in Ten Years, 1896 to 1905 (statistics shown by the stereopticon),
   Principal George R. Swain, Bay City High School.
2. Discussion of Principal Swain's paper,
   Principal David Mackenzie, Central High School, Detroit.
   Professor B. L. D'Ooge, Michigan State Normal College. (See also No. 13.)
3. Elision in Latin Verse,
   Professor Albert G. Harkness, Brown University.
4. Recent Excavations of Roman Remains in Britain: Silchester and Caerwent,*
   Dr. George H. Allen, University of Cincinnati.
   This paper will be printed in full, with illustrations, in *Records of the Past*, early next fall.
5. Some Ancient Roman Lamps,*
   Professor E. W. Clark, Ripon College, Wisconsin.
   Printed in full, with illustrations, in *Records of the Past*, for June.
6. The "More Ancient" Dionysia at Athens: A Note on Thucyd. II, 15,
   Professor Edward Capps, University of Chicago.
   To be published in full in *Classical Philology*, Vol. I, No. 4.
7. Is the Aeneid a Complete Poem?
   Principal Maude A. Isherwood, Grand Haven High School.

Thursday Afternoon

SYMPOSIUM†

on the value of literary, and particularly classical, studies as a preparation for the study of the professions.

8. The study of Greek and Latin as a preparation for the Study of Medicine,
   Dr. Victor C. Vaughan, Dean of the Department of Medicine and Surgery, University of Michigan.

*Illustrated with the stereopticon.

†The Symposium will be continued, with a discussion of the value of humanistic studies as a preparation for the study of Law and of Theology, at the Classical Conference of 1907.

9. Discussion of Dr. Vaughan's paper,
   Dr. Charles B. G. de Nancrede, Professor of Surgery, University of Michigan.
10. The Place of Humanistic Studies in the Preparation of a Student of Medicine,
   Dr. Wilbert B. Hinsdale, Dean of the Homœpathic Medical College, University of Michigan.
11. The Value of Humanistic Studies as a Preparation for the Study of Engineering,
   Herbert C. Sadler, Professor of Naval Architecture, University of Michigan.
12. Discussion of Professor Sadler's paper,
   Gardner S. Williams, Professor of Civil and Hydraulic Engineering, University of Michigan.
   George W. Patterson, Professor of Electrical Engineering, University of Michigan.
   J. B. Davis, Associate Dean of the Department of Engineering, University of Michigan.

The "Symposium" is printed in full in the *School Review* for June.

13. Five-minute discussions of this subject, and of the conditions revealed by Principal Swain's paper (No. 1),
   Principal F. L. Bliss, University School, Detroit.
   Superintendent W. G. Coburn, Battle Creek.
   Principal J. R. Bishop, Eastern High School, Detroit.

JOINT SESSION OF THE CLASSICAL AND MODERN LANGUAGE CONFERENCES

Thursday Evening

14. The Survival of the Classical Epic Tradition in Mediæval Literature,
   Dr. George L. Hamilton, University of Michigan.
15. The Influence of the Roman Law upon the Legal Systems of Modern Europe and America,
   Professor Joseph H. Drake, University of Michigan.

Friday Afternoon

16. The Autobiographical Element in Latin Literature and Inscriptions,
   Professor Henry H. Armstrong, Juniata College, Pennsylvania.
17. The Birth of Venus: A Greek Relief and a Renaissance painting,*
   Dr. Samuel A. Jeffers, California State Normal School, Pennsylvania.

To be published in full in *Records of the Past* for July.

*Illustrated with the stereopticon.

18. The Tenth Satire of Juvenal and Dr. Johnson's Vanity of Human Wishes,
    Mr. Frank E. Potter, Geneva High School, New York.
19. Present Schools and Theories of Latin Grammar.
    Professor John C. Rolfe, University of Pennsylvania.
    This will be published in the *School Review*.
20. Maron: A Mythological Study,
    Dr. Charles B. Newcomer, University of Michigan.
    To be published in full in *Classical Philology*.
21. The Roman Forum in the Summer of 1905,*
    Professor Walter Dennison, University of Michigan.
22. Question Box.
    All persons attending the Conference are invited to hand to the presiding officer on Friday afternoon any questions which they would like to have discussed at the Classical Conference of 1907; and to make suggestions regarding the speakers whom they would be pleased to hear.

CONFERENCE OF PHYSICS AND CHEMISTRY

Thursday Afternoon

1. The Equivalent Weight of Magnesium,
   Mr. E. A. Clemans, Central High School, Detroit.
2. Address: Are the Elements the Ultimate Constituents?
   Professor S. L. Bigelow, University of Michigan.
3. The Chemistry of the Bread We Eat,
   Mr. DeForest Ross, High School, Ypsilanti.
4. The Reference Library for Chemistry,
   Professor B. W. Peet, State Normal College.
5. Student's Method for Determining the Volume Weight of Hydrogen,
   Mr. R. R. Putnam, Eastern High School, Detroit.
6. A Series of Combining Weight Determinations,
   Mr. J. W. Matthews, Western High School, Detroit.
7. Method of Classifying the Inorganic Acids for Analysis,
   Professor W. S. Leavenworth, Olivet College.

Friday Afternoon

1. An Experiment in Thermal Conductivity,
   Mr. H. L. Curtis, Michigan Agricultural College.
2. The Use of the Alternating Current in the High School.
   Mr. H. L. Parrott, Saginaw.
3. Alternating Current Experiments,
   Mr. A. O. Wilkinson, Western High School, Detroit.

4. Address: The South African Meeting of the British Association for the Advancement of Science. (Ilustrated by stereopticon), Professor Henry S. Carhart, University of Michigan.
5. The Entrance Requirements in Physics and its Relation to the Physics of the College Course,
   Professor N. F. Smith, Olivet College.
   Professor C. W. Green, Albion College.
6. Boyle's Law Apparatus,
   Mr. C. D. Carpenter, Michigan State Normal College.

Saturday Afternoon

1. A Model for an Adjustable Cross-bar for a Laboratory Table,
   Mr. C. M. Bronson, Toledo, Ohio.
2. The Undercooling of Acetic Acid,
   Mr. C. F. Adams, Central High School, Detroit.
3. The Nernst Lamp in the Laboratory and Simple Experiments on Radio-Activity,
   Professor Fred N. Gorton, Michigan State Normal College.
4. A Convenient and Inexpensive Adjustment for a Galvanometer Scale,
   Mr. W. H. Hawkes, Ann Arbor High School.
5. A Simple Apparatus for Parallel Forces,
   Mr. DeForrest Ross, Ypsilanti High School.
6. An Apparatus for the Parallelogram of Forces,
   Mr. M. A. Cobb, Lansing High School.
7. Apparatus for Demonstrating Laws of Fluid Pressure,
   Mr. H. C. Krenerick, Berwyn, Ill.

JOINT MEETING BIOLOGICAL CONFERENCE AND SCIENCE TEACHING

Friday Afternoon

1. Laboratory Work in Biology, as Related to Field Work,
   Dr. J. G. Needham, Lake Forest College, Ill.
2. Laboratory Work in Biology, its Nature, Conduct and Value,
   Dr. Louis Murbach, Central High School, Detroit.
3. Laboratory Work in Physiography, as Related to Field Work,
   Professor M. S. W. Jefferson, State Normal College, Ypsilanti.
4. Laboratory Work in Geography,
   Professor L. H. Wood, Western State Normal School, Kalamazoo.

MATHEMATICAL CONFERENCE

Friday Afternoon

1. Mathematics in and below the High School,
   Mr. L. D. Wines, Ann Arbor High School.
2. The Teaching of the Theory of Interest and Insurance Mathematics in Universities, Colleges, and High Schools of this Country,
   Professor J. W. Glover, University of Michigan.
3. Geometry as an Experimental Science.
   Dr. W. B. Ford, University of Michigan.

HISTORY CONFERENCE

Friday Afternoon

1. First Report of Committee on Recent Publications of Special Interest to Teachers of History,
   Principal Webster Cook, Saginaw, Chairman of the Committee.
2. The Significance of Party Organization in American History,
   Professor Andrew C. McLaughlin, University of Michigan.
3. Business, including report of the Committee on Organization.
4. Round-Table Conference on the Work in Ancient History. Room 2, Tappan Hall.
   Leader, Miss Edith Kimball, Eastern High School, Detroit.

Questions for Discussion:

(a) How may we best secure the interest of the first year pupils?
(b) To what extent should we teach the constitutional history of Greece and Rome in this first year?

5. Round-Table Conference on the Work in Medieval and Modern History. Room 7, Tappan Hall.
   Leader, Mr. Charles H. Estrich, Central State Normal, Mt. Pleasant.

Questions for Discussion:

(a) How can we best establish the correlation of events in the different European nations?
(b) How can we cover the important developments of the medieval period, and find time to give an adequate idea of the present situation in Europe?

MODERN LANGUAGE CONFERENCE

Friday Afternoon

1. Some Experiences in Teaching French,
   Miss Ethel Gregg, Central High School, Detroit.

2. Essentials often Disregarded in the Teaching of Advanced German in Secondary Schools,
   Miss Carolyn A. Humphrey, Muskegon High School.
3. What Should be the Nature of the Sentences used in Drill in Beginning French Classes?
   Professor H. R. Brush, Hope College.
4. The Direct Method,
   Miss Marie Zimmerman, Saginaw E. S. High School.
5. Some Indispensable Factors for Americans Teaching Foreign Language and Literature,
   Professor J. Perry Worden, Kalamazoo College.

Saturday Morning

1. Recent Theory and Practice in French Verse,
   Professor H. P. Thieme, University of Michigan.
2. Resume of the New International Language "Esperanto,"
   Professor Frederick Lutz, Albion College.
3. Schiller and Goethe,
   Dr. Ewald Boucke, University of Michigan.
4. The Lyrism of Heine,
   Dr. Carl E. Eggert, University of Michigan.
5. The Pedagogical Ideals of Herder,
   Mr. James A. Campbell, University of Michigan.

CONFERENCE OF RHETORIC AND ENGLISH COMPOSITION

Friday Afternoon

1. Informal Talk, "On the Value of Making Things Unpleasant in Education,"
   Professor F. N. Scott, University of Michigan.
2. Topics for Discussion:
   (a) What parts or features of instruction in English composition have been found to be a waste of time?
   (b) To what extent, and in what particulars, is the correction of Essays effective?
   (c) Should Composition Work be suspended during any part of the High School course?
   (d) How much of Rhetorical Theory is indispensable in Secondary Instruction?

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Wagner, T. E.....Delray
Watkins, P. H.....Ithica
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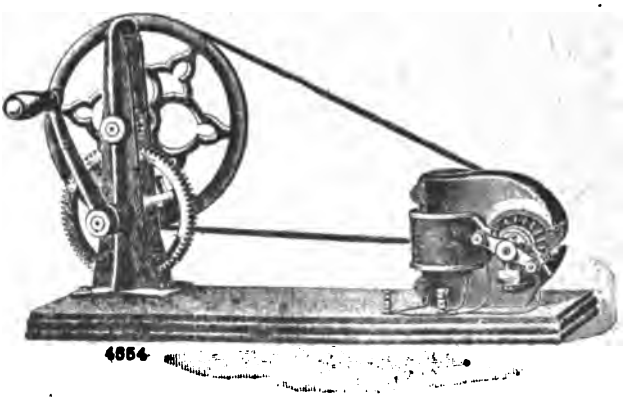

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